Aaboud, M. and Aad, G. and Abbott, B. and Abdallah, J. and Abdinov, O. and Abeloos, B. and Aben, R. and AbouZeid, O.S. and Abraham, N.L. and Abramowicz, H. and Abreu, H. and Abreu, R. and Abulaiti, Y. and Acharya, B.S. and Adachi, S. and Adamczyk, L. and Adams, D.L. and Adelman, J. and Adomeit, S. and Adye, T. and Affolder, A.A. and Agatonovic-Jovin, T. and Aguilar-Saavedra, J.A. and Ahlen, S.P. and Ahmadov, F. and Aielli, G. and Akerstedt, H. and Åkesson, T.P.A. and Akimov, A.V. and Alberghi, G.L. and Albert, J. and Albrand, S. and Alconada Verzini, M.J. and Aleksa, M. and Aleksandrov, I.N. and Alexa, C. and Alexander, G. and Alexopoulos, T. and Alhroob, M. and Ali, B. and Aliev, M. and Alimonti, G. and Alison, J. and Alkire, S.P. and Allbrooke, B.M.M. and Allen, B.W. and Allport, P.P. and Aloisio, A. and Alonso, A. and Alonso, F. and Alpigiani, C. and Alshehri, A.A. and Alstaty, M. and Alvarez Gonzalez, B. and Álvarez Piqueras, D. and Alviggi, M.G. and Amadio, B.T. and Amako, K. and Amaral Coutinho, Y. and Amelung, C. and Amidei, D. and Amor Dos Santos, S.P. and Amorim, A. and Amoroso, S. and Amundsen, G. and Anastopoulos, C. and Ancu, L.S. and Andari, N. and Andeen, T. and Anders, C.F. and Anders, G. and Anders, J.K. and Anderson, K.J. and Andreazza, A. and Andrei, V. and Angelidakis, S. and Angelozzi, I. and Angerami, A. and Anghinolfi, F. and Anisenkov, A.V. and Anjos, N. and Annovi, A. and Antel, C. and Antonelli, M. and Antonov, A. and Anulli, F. and Aoki, M. and Aperio Bella, L. and Arabidze, G. and Arai, Y. and Araque, J.P. and Arce, A.T.H. and Arduh, F.A. and Arguin, J-F. and Argyropoulos, S. and Arik, M. and Armbruster, A.J. and Armitage, L.J. and Arnaez, O. and Arnold, H. and Arratia, M. and Arslan, O. and Artamonov, A. and Artoni, G. and Artz, S. and Asai, S. and Asbah, N. and Ashkenazi, A. and Åsman, B. and Asquith, L. and Assamagan, K. and Astalos, R. and Atkinson, M. and Atlay, N.B. and Augsten, K. and Avolio, G. and Axen, B. and Ayoub, M.K. and Azuelos, G. and Baak, M.A. and Baas, A.E. and Baca, M.J. and Bachacou, H. and Bachas, K. and Backes, M. and Backhaus, M. and Bagiacchi, P. and Bagnaia, P. and Bai, Y. and Baines, J.T. and Baker, O.K. and Baldin, E.M. and Balek, P. and Balestri, T. and Balli, F. and Balunas, W.K. and Banas, E. and Banerjee, Sw. and Bannoura, A.A.E. and Barak, L. and Barberio, E.L. and Barberis, D. and Barbero, M. and Barillari, T. and Barisits, M-S and Barklow, T. and Barlow, N. and Barnes, S.L. and Barnett, B.M. and Barnett, R.M. and Barnovska-Blenessy, Z. and Baroncelli, A. and Barone, G. and Barr, A.J. and Barranco Navarro, L. and Barreiro, F. and Barreiro Guimarães da Costa, J. and Bartoldus, R. and Barton, A.E. and Bartos, P. and Basalaev, A. and Bassalat, A. and Bates, R.L. and Batista, S.J. and Batley, J.R. and Battaglia, M. and Bauce, M. and Bauer, F. and Bawa, H.S. and Beacham, J.B. and Beattie, M.D. and Beau, T. and Beauchemin, P.H. and Bechtle, P. and Beck, H.P. and Becker, K. and Becker, M. and Beckingham, M. and Becot, C. and Beddall, A.J. and Beddall, A. and Bednyakov, V.A. and Bedognetti, M. and Bee, C.P. and Beemster, L.J. and Beermann, T.A. and Begel, M. and Behr, J.K. and Belanger-Champagne, C. and Bell, A.S. and Bella, G. and Bellagamba, L. and Bellerive, A. and Bellomo, M. and Belotskiy, K. and Beltramello, O. and Belyaev, N.L. and Benary, O. and Benchekroun, D. and Bender, M. and Bendtz, K. and Benekos, N. and Benhammou, Y. and Benhar Noccioli, E. and Benitez, J. and Benjamin, D.P. and Bensinger, J.R. and Bentvelsen, S. and Beresford, L. and Beretta, M. and Berge, D. and Bergeaas Kuutmann, E. and Berger, N. and Beringer, J. and Berlendis, S. and Bernard, N.R. and Bernius, C. and Bernlochner, F.U. and Berry, T. and Berta, P. and Bertella, C. and Bertoli, G. and Bertolucci, F. and Bertram, I.A. and Bertsche, C. and Bertsche, D. and Besjes, G.J. and Bessidskaia Bylund, O. and Bessner, M. and Besson, N. and Betancourt, C. and Bethani, A. and Bethke, S. and Bevan, A.J. and Bianchi, R.M. and Bianchini, L. and Bianco, M. and Biebel, O. and Biedermann, D. and Bielski, R. and Biesuz, N.V. and

Biglietti, M. and Bilbao De Mendizabal, J. and Billoud, T.R.V. and Bilokon, H. and Bindi, M. and Binet, S. and Bingul, A. and Bini, C. and Biondi, S. and Bisanz, T. and Bjergaard, D.M. and Black, C.W. and Black, J.E. and Black, K.M. and Blackburn, D. and Blair, R.E. and Blanchard, J.-B. and Blazek, T. and Bloch, I. and Blocker, C. and Blue, A. and Blum, W. and Blumenschein, U. and Blunier, S. and Bobbink, G.J. and Bobrovnikov, V.S. and Bocchetta, S.S. and Bocci, A. and Bock, C. and Boehler, M. and Boerner, D. and Bogaerts, J.A. and Bogavac, D. and Bogdanchikov, A.G. and Bohm, C. and Boisvert, V. and Bokan, P. and Bold, T. and Boldyrev, A.S. and Bomben, M. and Bona, M. and Boonekamp, M. and Borisov, A. and Borissov, G. and Bortfeldt, J. and Bortoletto, D. and Bortolotto, V. and Bos, K. and Boscherini, D. and Bosman, M. and Bossio Sola, J.D. and Boudreau, J. and Bouffard, J. and Bouhova-Thacker, E.V. and Boumediene, D. and Bourdarios, C. and Boutle, S.K. and Boveia, A. and Boyd, J. and Boyko, I.R. and Bracinik, J. and Brandt, A. and Brandt, G. and Brandt, O. and Bratzler, U. and Brau, B. and Brau, J.E. and Breaden Madden, W.D. and Brendlinger, K. and Brennan, A.J. and Brenner, L. and Brenner, R. and Bressler, S. and Bristow, T.M. and Britton, D. and Britzger, D. and Brochu, F.M. and Brock, I. and Brock, R. and Brooijmans, G. and Brooks, T. and Brooks, W.K. and Brosamer, J. and Brost, E. and Broughton, J.H and Bruckman de Renstrom, P.A. and Bruncko, D. and Bruneliere, R. and Bruni, A. and Bruni, G. and Bruni, L.S. and Brunt, BH and Bruschi, M. and Bruscino, N. and Bryant, P. and Bryngemark, L. and Buanes, T. and Buat, Q. and Buchholz, P. and Buckley, A.G. and Budagov, I.A. and Buehrer, F. and Bugge, M.K. and Bulekov, O. and Bullock, D. and Burckhart, H. and Burdin, S. and Burgard, C.D. and Burghgrave, B. and Burka, K. and Burke, S. and Burmeister, I. and Burr, J.T.P. and Busato, E. and Büscher, D. and Büscher, V. and Bussey, P. and Butler, J.M. and Buttar, C.M. and Butterworth, J.M. and Butti, P. and Buttinger, W. and Buzatu, A. and Buzykaev, A.R. and Cabrera Urbán, S. and Caforio, D. and Cairo, V.M. and Cakir, O. and Calace, N. and Calafiura, P. and Calandri, A. and Calderini, G. and Calfayan, P. and Callea, G. and Caloba, L.P. and Calvente Lopez, S. and Calvet, D. and Calvet, S. and Calvet, T.P. and Camacho Toro, R. and Camarda, S. and Camarri, P. and Cameron, D. and Caminal Armadans, R. and Camincher, C. and Campana, S. and Campanelli, M. and Camplani, A. and Campoverde, A. and Canale, V. and Canepa, A. and Cano Bret, M. and Cantero, J. and Cao, T. and Capeans Garrido, M.D.M. and Caprini, I. and Caprini, M. and Capua, M. and Carbone, R.M. and Cardarelli, R. and Cardillo, F. and Carli, I. and Carli, T. and Carlino, G. and Carminati, L. and Carney, R.M.D. and Caron, S. and Carquin, E. and Carrillo-Montoya, G.D. and Carter, J.R. and Carvalho, J. and Casadei, D. and Casado, M.P. and Casolino, M. and Casper, D.W. and Castaneda-Miranda, E. and Castelijn, R. and Castelli, A. and Castillo Gimenez, V. and Castro, N.F. and Catinaccio, A. and Catmore, J.R. and Cattai, A. and Caudron, J. and Cavaliere, V. and Cavallaro, E. and Cavalli, D. and Cavalli-Sforza, M. and Cavasinni, V. and Ceradini, F. and Cerda Alberich, L. and Cerqueira, A.S. and Cerri, A. and Cerrito, L. and Cerutti, F. and Cerv, M. and Cervelli, A. and Cetin, S.A. and Chafaq, A. and Chakraborty, D. and Chan, S.K. and Chan, Y.L. and Chang, P. and Chapman, J.D. and Charlton, D.G. and Chatterjee, A. and Chau, C.C. and Chavez Barajas, C.A. and Che, S. and Cheatham, S. and Chegwidden, A. and Chekanov, S. and Chekulaev, S.V. and Chelkov, G.A. and Chelstowska, M.A. and Chen, C. and Chen, H. and Chen, K. and Chen, S. and Chen, S. and Chen, X. and Chen, Y. and Cheng, H.C. and Cheng, H.J and Cheng, Y. and Cheplakov, A. and Cheremushkina, E. and Cherkaoui El Moursli, R. and Chernyatin, V. and Cheu, E. and Chevalier, L. and Chiarella, V. and Chiarelli, G. and Chiodini, G. and Chisholm, A.S. and Chitan, A. and Chizhov, M.V. and Choi, K. and Chomont, A.R. and Chouridou, S. and Chow, B.K.B. and Christodoulou, V. and Chromek-Burckhart, D. and Chudoba, J. and Chuinard, A.J. and Chwastowski, J.J. and Chytka, L. and Ciapetti, G. and Ciftci, A.K. and Cinca, D. and Cindro, V. and Cioara, I.A. and Ciocca, C. and Ciocio, A. and Cirotto, F. and Citron, Z.H. and Citterio, M. and Ciubancan, M. and Clark, A. and Clark, B.L. and Clark, M.R. and Clark, P.J. and Clarke, R.N. and Clement, C. and Coadou, Y. and Cobal, M. and Coccaro, A. and Cochran, J. and Colasurdo, L. and Cole, B. and Colijn, A.P. and Collot, J. and Colombo, T. and Compostella, G. and Conde Muiño, P. and Coniavitis, E. and Connell, S.H. and Connelly, I.A. and Consorti, V. and Constantinescu, S. and Conti, G. and Conventi, F. and Cooke, M. and Cooper, B.D. and Cooper-Sarkar, A.M. and Cormier, K.J.R. and Cornelissen, T. and Corradi, M. and Corriveau, F. and Cortes-Gonzalez, A. and Cortiana, G. and Costa, G. and Costa, M.J. and Costanzo, D. and Cottin, G. and Cowan, G. and Cox, B.E. and Cranmer, K. and Crawley, S.J. and Cree, G. and Crépé-Renaudin, S. and Crescioli, F. and Cribbs, W.A. and Crispin Ortuzar, M. and Cristinziani, M. and Croft, V. and Crosetti, G. and Cueto, A. and Cuhadar Donszelmann, T. and Cummings, J. and Curatolo, M. and Cúth, J. and Czirr, H. and Czodrowski, P. and D'amen, G. and D'Auria, S. and D'Onofrio, M. and Da Cunha Sargedas De Sousa, M.J. and Da Via, C. and Dabrowski, W. and Dado, T. and Dai, T. and Dale, O. and Dallaire, F. and Dallapiccola, C. and Dam, M. and Dandoy, J.R. and Dang, N.P. and Daniells, A.C. and Dann, N.S. and Danninger, M. and Dano Hoffmann, M. and Dao, V. and Darbo, G. and Darmora, S. and Dassoulas, J. and Dattagupta, A. and Davey, W. and David, C. and Davidek, T. and Davies, M. and Davison, P. and Dawe, E. and Dawson, I. and De, K. and de Asmundis, R. and De Benedetti, A. and De Castro, S. and De Cecco, S. and De Groot, N. and de Jong, P. and De la Torre, H. and De Lorenzi, F. and De Maria, A. and De Pedis, D. and De Salvo, A. and De Sanctis, U. and De Santo, A. and De Vivie De Regie, J.B. and Dearnaley, W.J. and Debbe, R. and Debenedetti, C. and Dedovich, D.V. and Dehghanian, N. and Deigaard, I. and Del Gaudio, M. and Del Peso, J. and Del Prete, T. and Delgove, D. and Deliot, F. and Delitzsch, C.M. and Dell'Acqua, A. and

Dell'Asta, L. and Dell'Orso, M. and Della Pietra, M. and della Volpe, D. and Delmastro, M. and Delsart, P.A. and DeMarco, D.A. and Demers, S. and Demichev, M. and Demilly, A. and Denisov, S.P. and Denysiuk, D. and Derendarz, D. and Derkaoui, J.E. and Derue, F. and Dervan, P. and Desch, K. and Deterre, C. and Dette, K. and Deviveiros, P.O. and Dewhurst, A. and Dhaliwal, S. and Di Ciaccio, A. and Di Ciaccio, L. and Di Clemente, W.K. and Di Donato, C. and Di Girolamo, A. and Di Girolamo, B. and Di Micco, B. and Di Nardo, R. and Di Simone, A. and Di Sipio, R. and Di Valentino, D. and Diaconu, C. and Diamond, M. and Dias, F.A. and Diaz, M.A. and Diehl, E.B. and Dietrich, J. and Díez Cornell, S. and Dimitrievska, A. and Dingfelder, J. and Dita, P. and Dita, S. and Dittus, F. and Djama, F. and Djobava, T. and Djuvsland, J.I. and do Vale, M.A.B. and Dobos, D. and Dobre, M. and Doglioni, C. and Dolejsi, J. and Dolezal, Z. and Donadelli, M. and Donati, S. and Dondero, P. and Donini, J. and Dopke, J. and Doria, A. and Dova, M.T. and Doyle, A.T. and Drechsler, E. and Dris, M. and Du, Y. and Duarte-Campderros, J. and Duchovni, E. and Duckeck, G. and Ducu, O.A. and Duda, D. and Dudarev, A. and Chr. Dudder, A. and Duffield, E.M. and Duflot, L. and Dührssen, M. and Dumancic, M. and Dunford, M. and Duran Yildiz, H. and Düren, M. and Durglishvili, A. and Duschinger, D. and Dutta, B. and Dyndal, M. and Eckardt, C. and Ecker, K.M. and Edgar, R.C. and Edwards, N.C. and Eifert, T. and Eigen, G. and Einsweiler, K. and Ekelof, T. and El Kacimi, M. and Ellajosyula, V. and Ellert, M. and Elles, S. and Ellinghaus, F. and Elliot, A.A. and Ellis, N. and Elmsheuser, J. and Elsing, M. and Emeliyanov, D. and Enari, Y. and Endner, O.C. and Ennis, J.S. and Erdmann, J. and Ereditato, A. and Ernis, G. and Ernst, J. and Ernst, M. and Errede, S. and Ertel, E. and Escalier, M. and Esch, H. and Escobar, C. and Esposito, B. and Etienvre, A.I. and Etzion, E. and Evans, H. and Ezhilov, A. and Ezzi, M. and Fabbri, F. and Fabbri, L. and Facini, G. and Fakhrutdinov, R.M. and Falciano, S. and Falla, R.J. and Faltova, J. and Fang, Y. and Fanti, M. and Farbin, A. and Farilla, A. and Farina, C. and Farina, E.M. and Farooque, T. and Farrell, S. and Farrington, S.M. and Farthouat, P. and Fassi, F. and Fassnacht, P. and Fassouliotis, D. and Faucci Giannelli, M. and Favareto, A. and Fawcett, W.J. and Fayard, L. and Fedin, O.L. and Fedorko, W. and Feigl, S. and Feligioni, L. and Feng, C. and Feng, E.J. and Feng, H. and Fenyuk, A.B. and Feremenga, L. and Fernandez Martinez, P. and Fernandez Perez, S. and Ferrando, J. and Ferrari, A. and Ferrari, P. and Ferrari, R. and Ferreira de Lima, D.E. and Ferrer, A. and Ferrere, D. and Ferretti, C. and Ferretto Parodi, A. and Fiedler, F. and Filipčič, A. and Filipuzzi, M. and Filthaut, F. and Fincke-Keeler, M. and Finelli, K.D. and Fiolhais, M.C.N. and Fiorini, L. and Firan, A. and Fischer, A. and Fischer, C. and Fischer, J. and Fisher, W.C. and Flaschel, N. and Fleck, I. and Fleischmann, P. and Fletcher, G.T. and Fletcher, R.R.M. and Flick, T. and Flores Castillo, L.R. and Flowerdew, M.J. and Forcolin, G.T. and Formica, A. and Forti, A. and Foster, A.G. and Fournier, D. and Fox, H. and Fracchia, S. and Francavilla, P. and Franchini, M. and Francis, D. and Franconi, L. and Franklin, M. and Frate, M. and Fraternali, M. and Freeborn, D. and Fressard-Batraneanu, S.M. and Friedrich, F. and Froidevaux, D. and Frost, J.A. and Fukunaga, C. and Fullana Torregrosa, E. and Fusayasu, T. and Fuster, J. and Gabaldon, C. and Gabizon, O. and Gabrielli, A. and Gabrielli, A. and Gach, G.P. and Gadatsch, S. and Gadomski, S. and Gagliardi, G. and Gagnon, L.G. and Gagnon, P. and Galea, C. and Galhardo, B. and Gallas, E.J. and Gallop, B.J. and Gallus, P. and Galster, G. and Gan, K.K. and Ganguly, S. and Gao, J. and Gao, Y. and Gao, Y.S. and Garay Walls, F.M. and García, C. and García Navarro, J.E. and Garcia-Sciveres, M. and Gardner, R.W. and Garelli, N. and Garonne, V. and Gascon Bravo, A. and Gasnikova, K. and Gatti, C. and Gaudiello, A. and Gaudio, G. and Gauthier, L. and Gavrilenko, I.L. and Gay, C. and Gaycken, G. and Gazis, E.N. and Gecse, Z. and Gee, C.N.P. and Geich-Gimbel, Ch. and Geisen, M. and Geisler, M.P. and Gellerstedt, K. and Gemme, C. and Genest, M.H. and Geng, C. and Gentile, S. and Gentsos, C. and George, S. and Gerbaudo, D. and Gershon, A. and Ghasemi, S. and Ghneimat, M. and Giacobbe, B. and Giagu, S. and Giannetti, P. and Gibbard, B. and Gibson, S.M. and Gignac, M. and Gilchriese, M. and Gillam, T.P.S. and Gillberg, D. and Gilles, G. and Gingrich, D.M. and Giokaris, N. and Giordani, M.P. and Giorgi, F.M. and Giorgi, F.M. and Giraud, P.F. and Giromini, P. and Giugni, D. and Giuli, F. and Giuliani, C. and Giulini, M. and Gjelsten, B.K. and Gkaitatzis, S. and Gkialas, I. and Gkougkousis, E.L. and Gladilin, L.K. and Glasman, C. and Glatzer, J. and Glaysher, P.C.F. and Glazov, A. and Goblirsch-Kolb, M. and Godlewski, J. and Goldfarb, S. and Golling, T. and Golubkov, D. and Gomes, A. and Gonçalo, R. and Goncalves Pinto Firmino Da Costa, J. and Gonella, G. and Gonella, L. and Gongadze, A. and González de la Hoz, S. and Gonzalez-Sevilla, S. and Goossens, L. and Gorbounov, P.A. and Gordon, H.A. and Gorelov, I. and Gorini, B. and Gorini, E. and Gorišek, A. and Gornicki, E. and Goshaw, A.T. and Gössling, C. and Gostkin, M.I. and Goudet, C.R. and Goujdami, D. and Goussiou, A.G. and Govender, N. and Gozani, E. and Graber, L. and Grabowska-Bold, I. and Gradin, P.O.J. and Grafström, P. and Gramling, J. and Gramstad, E. and Grancagnolo, S. and Gratchev, V. and Gravila, P.M. and Gray, H.M. and Graziani, E. and Greenwood, Z.D. and Grefe, C. and Gregersen, K. and Gregor, I.M. and Grenier, P. and Grevtsov, K. and Griffiths, J. and Grillo, A.A. and Grimm, K. and Grinstein, S. and Gris, Ph. and Grivaz, J.-F. and Groh, S. and Gross, E. and Grosse-Knetter, J. and Grossi, G.C. and Grout, Z.J. and Guan, L. and Guan, W. and Guenther, J. and Guescini, F. and Guest, D. and Gueta, O. and Gui, B. and Guido, E. and Guillemin, T. and Guindon, S. and Gul, U. and Gumpert, C. and Guo, J. and Guo, Y. and Gupta, R. and Gupta, S. and Gustavino, G. and Gutierrez, P. and Gutierrez Ortiz, N.G. and Gutschow, C. and Guyot, C. and Gwenlan, C. and Gwilliam, C.B. and Haas, A. and Haber, C. and Hadavand, H.K. and Haddad, N. and Hadef, A. and Hageböck, S. and Hagihara, M. and Hajduk, Z. and Hakobyan, H. and Haleem,

M. and Haley, J. and Halladjian, G. and Hallewell, G.D. and Hamacher, K. and Hamal, P. and Hamano, K. and Hamilton, A. and Hamity, G.N. and Hamnett, P.G. and Han, L. and Hanagaki, K. and Hanawa, K. and Hance, M. and Haney, B. and Hanke, P. and Hanna, R. and Hansen, J.B. and Hansen, J.D. and Hansen, M.C. and Hansen, P.H. and Hara, K. and Hard, A.S. and Harenberg, T. and Hariri, F. and Harkusha, S. and Harrington, R.D. and Harrison, P.F. and Hartjes, F. and Hartmann, N.M. and Hasegawa, M. and Hasegawa, Y. and Hasib, A. and Hassani, S. and Haug, S. and Hauser, R. and Hauswald, L. and Havranek, M. and Hawkes, C.M. and Hawkings, R.J. and Hayakawa, D. and Hayden, D. and Hays, C.P. and Hays, J.M. and Hayward, H.S. and Haywood, S.J. and Head, S.J. and Heck, T. and Hedberg, V. and Heelan, L. and Heim, S. and Heim, T. and Heinemann, B. and Heinrich, J.J. and Heinrich, L. and Heinz, C. and Hejbal, J. and Helary, L. and Hellman, S. and Helsens, C. and Henderson, J. and Henderson, R.C.W. and Heng, Y. and Henkelmann, S. and Henriques Correia, A.M. and Henrot-Versille, S. and Herbert, G.H. and Herde, H. and Herget, V. and Hernández Jiménez, Y. and Herten, G. and Hertenberger, R. and Hervas, L. and Hesketh, G.G. and Hessey, N.P. and Hetherly, J.W. and Hickling, R. and Higón-Rodriguez, E. and Hill, E. and Hill, J.C. and Hiller, K.H. and Hillier, S.J. and Hinchliffe, I. and Hines, E. and Hinman, R.R. and Hirose, M. and Hirschbuehl, D. and Hobbs, J. and Hod, N. and Hodgkinson, M.C. and Hodgson, P. and Hoecker, A. and Hoeferkamp, M.R. and Hoenig, F. and Hohn, D. and Holmes, T.R. and Homann, M. and Honda, T. and Hong, T.M. and Hooberman, B.H. and Hopkins, W.H. and Horii, Y. and Horton, A.J. and Hostachy, J-Y. and Hou, S. and Hoummada, A. and Howarth, J. and Hoya, J. and Hrabovsky, M. and Hristova, I. and Hrivnac, J. and Hryn'ova, T. and Hrynevich, A. and Hsu, C. and Hsu, P.J. and Hsu, S.-C. and Hu, Q. and Hu, S. and Huang, Y. and Hubacek, Z. and Hubaut, F. and Huegging, F. and Huffman, T.B. and Hughes, E.W. and Hughes, G. and Huhtinen, M. and Huo, P. and Huseynov, N. and Huston, J. and Huth, J. and Iacobucci, G. and Iakovidis, G. and Ibragimov, I. and Iconomidou-Fayard, L. and Ideal, E. and Idrissi, Z. and Iengo, P. and Igonkina, O. and Iizawa, T. and Ikegami, Y. and Ikeno, M. and Ilchenko, Y. and Iliadis, D. and Ilic, N. and Ince, T. and Introzzi, G. and Ioannou, P. and Iodice, M. and Iordanidou, K. and Ippolito, V. and Ishijima, N. and Ishino, M. and Ishitsuka, M. and Ishmukhametov, R. and Issever, C. and Istin, S. and Ito, F. and Iturbe Ponce, J.M. and Iuppa, R. and Iwanski, W. and Iwasaki, H. and Izen, J.M. and Izzo, V. and Jabbar, S. and Jackson, B. and Jackson, P. and Jain, V. and Jakobi, K.B. and Jakobs, K. and Jakobsen, S. and Jakoubek, T. and Jamin, D.O. and Jana, D.K. and Jansky, R. and Janssen, J. and Janus, M. and Jarlskog, G. and Javadov, N. and Javůrek, T. and Jeanneau, F. and Jeanty, L. and Jeng, G.-Y. and Jennens, D. and Jenni, P. and Jeske, C. and Jézéquel, S. and Ji, H. and Jia, J. and Jiang, H. and Jiang, Y. and Jiang, Z. and Jiggins, S. and Jimenez Pena, J. and Jin, S. and Jinaru, A. and Jinnouchi, O. and Jivan, H. and Johansson, P. and Johns, K.A. and Johnson, W.J. and Jon-And, K. and Jones, G. and Jones, R.W.L. and Jones, S. and Jones, T.J. and Jongmanns, J. and Jorge, P.M. and Jovicevic, J. and Ju, X. and Juste Rozas, A. and Köhler, M.K. and Kaczmarska, A. and Kado, M. and Kagan, H. and Kagan, M. and Kahn, S.J. and Kaji, T. and Kajomovitz, E. and Kalderon, C.W. and Kaluza, A. and Kama, S. and Kamenshchikov, A. and Kanaya, N. and Kaneti, S. and Kanjir, L. and Kantserov, V.A. and Kanzaki, J. and Kaplan, B. and Kaplan, L.S. and Kapliy, A. and Kar, D. and Karakostas, K. and Karamaoun, A. and Karastathis, N. and Kareem, M.J. and Karentzos, E. and Karnevskiy, M. and Karpov, S.N. and Karpova, Z.M. and Karthik, K. and Kartvelishvili, V. and Karyukhin, A.N. and Kasahara, K. and Kashif, L. and Kass, R.D. and Kastanas, A. and Kataoka, Y. and Kato, C. and Katre, A. and Katzy, J. and Kawade, K. and Kawagoe, K. and Kawamoto, T. and Kawamura, G. and Kazanin, V.F. and Keeler, R. and Kehoe, R. and Keller, J.S. and Kempster, J.J. and Keoshkerian, H. and Kepka, O. and Kerševan, B.P. and Kersten, S. and Keyes, R.A. and Khader, M. and Khalil-zada, F. and Khanov, A. and Kharlamov, A.G. and Kharlamova, T. and Khoo, T.J. and Khovanskiy, V. and Khramov, E. and Khubua, J. and Kido, S. and Kilby, C.R. and Kim, H.Y. and Kim, S.H. and Kim, Y.K. and Kimura, N. and Kind, O.M. and King, B.T. and King, M. and Kirk, J. and Kiryunin, A.E. and Kishimoto, T. and Kisielewska, D. and Kiss, F. and Kiuchi, K. and Kivernyk, O. and Kladiva, E. and Klein, M.H. and Klein, M. and Klein, U. and Kleinknecht, K. and Klimek, P. and Klimentov, A. and Klingenberg, R. and Klinger, J.A. and Klioutchnikova, T. and Kluge, E.-E. and Kluit, P. and Kluth, S. and Knapik, J. and Kneringer, E. and Knoops, E.B.F.G. and Knue, A. and Kobayashi, A. and Kobayashi, D. and Kobayashi, T. and Kobel, M. and Kocian, M. and Kodys, P. and Koehler, N.M. and Koffas, T. and Koffeman, E. and Koi, T. and Kolanoski, H. and Kolb, M. and Koletsou, I. and Komar, A.A. and Komori, Y. and Kondo, T. and Kondrashova, N. and Köneke, K. and König, A.C. and Kono, T. and Konoplich, R. and Konstantinidis, N. and Kopeliansky, R. and Koperny, S. and Köpke, L. and Kopp, A.K. and Korcyl, K. and Kordas, K. and Korn, A. and Korol, A.A. and Korolkov, I. and Korolkova, E.V. and Kortner, O. and Kortner, S. and Kosek, T. and Kostyukhin, V.V. and Kotwal, A. and Koulouris, A. and Kourkoumeli-Charalampidi, A. and Kourkoumelis, C. and Kouskoura, V. and Kowalewska, A.B. and Kowalewski, R. and Kowalski, T.Z. and Kozakai, C. and Kozanecki, W. and Kozhin, A.S. and Kramarenko, V.A. and Kramberger, G. and Krasnopevtsev, D. and Krasny, M.W. and Krasznahorkay, A. and Kravchenko, A. and Kretz, M. and Kretzschmar, J. and Kreutzfeldt, K. and Krieger, P. and Krizka, K. and Kroeninger, K. and Kroha, H. and Kroll, J. and Kroseberg, J. and Krstic, J. and Kruchonak, U. and Krüger, H. and Krumnack, N. and Kruse, M.C. and Kruskal, M. and Kubota, T. and Kucuk, H. and Kuday, S. and Kuechler, J.T. and Kuehn, S. and Kugel, A. and Kuger, F. and Kuhl, A. and Kuhl, T. and Kukhtin, V. and Kukla, R. and Kulchitsky, Y. and Kuleshov, S. and Kuna, M. and Kunigo, T. and Kupco, A. and Kurashige,

H. and Kurochkin, Y.A. and Kus, V. and Kuwertz, E.S. and Kuze, M. and Kvita, J. and Kwan, T. and Kyriazopoulos, D. and La Rosa, A. and La Rosa Navarro, J.L. and La Rotonda, L. and Lacasta, C. and Lacava, F. and Lacey, J. and Lacker, H. and Lacour, D. and Lacuesta, V.R. and Ladygin, E. and Lafaye, R. and Laforge, B. and Lagouri, T. and Lai, S. and Lammers, S. and Lampl, W. and Lançon, E. and Landgraf, U. and Landon, M.P.J. and Lanfermann, M.C. and Lang, V.S. and Lange, J.C. and Lankford, A.J. and Lanni, F. and Lantzsch, K. and Lanza, A. and Laplace, S. and Lapoire, C. and Laporte, J.F. and Lari, T. and Lasagni Manghi, F. and Lassnig, M. and Laurelli, P. and Lavrijsen, W. and Law, A.T. and Laycock, P. and Lazovich, T. and Lazzaroni, M. and Le, B. and Le Dortz, O. and Le Guirriec, E. and Le Quilleuc, E.P. and LeBlanc, M. and LeCompte, T. and Ledroit-Guillon, F. and Lee, C.A. and Lee, S.C. and Lee, L. and Lefebvre, B. and Lefebvre, G. and Lefebvre, M. and Legger, F. and Leggett, C. and Lehan, A. and Lehmann Miotto, G. and Lei, X. and Leight, W.A. and Leister, A.G. and Leite, M.A.L. and Leitner, R. and Lellouch, D. and Lemmer, B. and Leney, K.J.C. and Lenz, T. and Lenzi, B. and Leone, R. and Leone, S. and Leonidopoulos, C. and Leontsinis, S. and Lerner, G. and Leroy, C. and Lesage, A.A.J. and Lester, C.G. and Levchenko, M. and Levêque, J. and Levin, D. and Levinson, L.J. and Levy, M. and Lewis, D. and Leyko, A.M. and Leyton, M. and Li, B. and Li, C. and Li, H. and Li, H.L. and Li, L. and Li, L. and Li, Q. and Li, S. and Li, X. and Li, Y. and Liang, Z. and Liberti, B. and Liblong, A. and Lichard, P. and Lie, K. and Liebal, J. and Liebig, W. and Limosani, A. and Lin, S.C. and Lin, T.H. and Lindquist, B.E. and Lionti, A.E. and Lipeles, E. and Lipniacka, A. and Lisovyi, M. and Liss, T.M. and Lister, A. and Litke, A.M. and Liu, B. and Liu, D. and Liu, H. and Liu, H. and Liu, J. and Liu, J.B. and Liu, K. and Liu, L. and Liu, M. and Liu, M. and Liu, Y.L. and Liu, Y. and Livan, M. and Lleres, A. and Llorente Merino, J. and Lloyd, S.L. and Lo Sterzo, F. and Lobodzinska, E.M. and Loch, P. and Loebinger, F.K. and Loew, K.M. and Loginov, A. and Lohse, T. and Lohwasser, K. and Lokajicek, M. and Long, B.A. and Long, J.D. and Long, R.E. and Longo, L. and Looper, K.A. and López, J.A. and Lopez Mateos, D. and Lopez Paredes, B. and Lopez Paz, I. and Lopez Solis, A. and Lorenz, J. and Lorenzo Martinez, N. and Losada, M. and Lösel, P.J. and Lou, X. and Lounis, A. and Love, J. and Love, P.A. and Lu, H. and Lu, N. and Lubatti, H.J. and Luci, C. and Lucotte, A. and Luedtke, C. and Luehring, F. and Lukas, W. and Luminari, L. and Lundberg, O. and Lund-Jensen, B. and Luzi, P.M. and Lynn, D. and Lysak, R. and Lytken, E. and Lyubushkin, V. and Ma, H. and Ma, L.L. and Ma, Y. and Maccarrone, G. and Macchiolo, A. and Macdonald, C.M. and Maček, B. and Machado Miguens, J. and Madaffari, D. and Madar, R. and Maddocks, H.J. and Mader, W.F. and Madsen, A. and Maeda, J. and Maeland, S. and Maeno, T. and Maevskiy, A. and Magradze, E. and Mahlstedt, J. and Maiani, C. and Maidantchik, C. and Maier, A.A. and Maier, T. and Maio, A. and Majewski, S. and Makida, Y. and Makovec, N. and Malaescu, B. and Malecki, Pa. and Maleev, V.P. and Malek, F. and Mallik, U. and Malon, D. and Malone, C. and Malone, C. and Maltezos, S. and Malyukov, S. and Mamuzic, J. and Mancini, G. and Mandelli, L. and Mandić, I. and Maneira, J. and Manhaes de Andrade Filho, L. and Manjarres Ramos, J. and Mann, A. and Manousos, A. and Mansoulie, B. and Mansour, J.D. and Mantifel, R. and Mantoani, M. and Manzoni, S. and Mapelli, L. and Marceca, G. and March, L. and Marchiori, G. and Marcisovsky, M. and Marjanovic, M. and Marley, D.E. and Marroquim, F. and Marsden, S.P. and Marshall, Z. and Marti-Garcia, S. and Martin, B. and Martin, T.A. and Martin, V.J. and Martin dit Latour, B. and Martinez, M. and Martinez Outschoorn, V.I. and Martin-Haugh, S. and Martoiu, V.S. and Martyniuk, A.C. and Marzin, A. and Masetti, L. and Mashimo, T. and Mashinistov, R. and Masik, J. and Maslennikov, A.L. and Massa, I. and Massa, L. and Mastrandrea, P. and Mastroberardino, A. and Masubuchi, T. and Mättig, P. and Mattmann, J. and Maurer, J. and Maxfield, S.J. and Maximov, D.A. and Mazini, R. and Maznas, I. and Mazza, S.M. and Mc Fadden, N.C. and Mc Goldrick, G. and Mc Kee, S.P. and McCarn, A. and McCarthy, R.L. and McCarthy, T.G. and McClymont, L.I. and McDonald, E.F. and Mcfayden, J.A. and Mchedlidze, G. and McMahon, S.J. and McPherson, R.A. and Medinnis, M. and Meehan, S. and Mehlhase, S. and Mehta, A. and Meier, K. and Meineck, C. and Meirose, B. and Melini, D. and Mellado Garcia, B.R. and Melo, M. and Meloni, F. and Meng, X. and Mengarelli, A. and Menke, S. and Meoni, E. and Mergelmeyer, S. and Mermod, P. and Merola, L. and Meroni, C. and Merritt, F.S. and Messina, A. and Metcalfe, J. and Mete, A.S. and Meyer, C. and Meyer, C. and Meyer, J-P. and Meyer, J. and Meyer Zu Theenhausen, H. and Miano, F. and Middleton, R.P. and Miglioranzi, S. and Mijović, L. and Mikenberg, G. and Mikestikova, M. and Mikuž, M. and Milesi, M. and Milic, A. and Miller, D.W. and Mills, C. and Milov, A. and Milstead, D.A. and Minaenko, A.A. and Minami, Y. and Minashvili, I.A. and Mincer, A.I. and Mindur, B. and Mineev, M. and Minegishi, Y. and Ming, Y. and Mir, L.M. and Mistry, K.P. and Mitani, T. and Mitrevski, J. and Mitsou, V.A. and Miucci, A. and Miyagawa, P.S. and Mjörnmark, J.U. and Mlynarikova, M. and Moa, T. and Mochizuki, K. and Mohapatra, S. and Molander, S. and Moles-Valls, R. and Monden, R. and Mondragon, M.C. and Mönig, K. and Monk, J. and Monnier, E. and Montalbano, A. and Montejo Berlingen, J. and Monticelli, F. and Monzani, S. and Moore, R.W. and Morange, N. and Moreno, D. and Moreno Llácer, M. and Morettini, P. and Morgenstern, S. and Mori, D. and Mori, T. and Morii, M. and Morinaga, M. and Morisbak, V. and Moritz, S. and Morley, A.K. and Mornacchi, G. and Morris, J.D. and Mortensen, S.S. and Morvaj, L. and Mosidze, M. and Moss, J. and Motohashi, K. and Mount, R. and Mountricha, E. and Moyse, E.J.W. and Muanza, S. and Mudd, R.D. and Mueller, F. and Mueller, J. and Mueller, R.S.P. and Mueller, T. and Muenstermann, D. and Mullen, P. and Mullier, G.A. and Munoz Sanchez, F.J. and Murillo Quijada, J.A. and Murray, W.J. and Musheghyan, H. and Muškinja, M. and Myagkov, A.G. and Myska, M. and Nachman, B.P. and Nackenhorst, O. and Nagai, K. and Nagai, R. and Nagano, K. and Nagasaka, Y. and Nagata, K. and Nagel, M. and Nagy, E. and Nairz, A.M. and Nakahama, Y. and Nakamura, K. and Nakamura, T. and Nakano, I. and Naranjo Garcia, R.F. and Narayan, R. and Narrias Villar, D.I. and Naryshkin, I. and Naumann, T. and Navarro, G. and Nayyar, R. and Neal, H.A. and Nechaeva, P.Yu. and Neep, T.J. and Negri, A. and Negrini, M. and Nektarijevic, S. and Nellist, C. and Nelson, A. and Nemecek, S. and Nemethy, P. and Nepomuceno, A.A. and Nessi, M. and Neubauer, M.S. and Neumann, M. and Neves, R.M. and Nevski, P. and Newman, P.R. and Nguyen, D.H. and Nguyen Manh, T. and Nickerson, R.B. and Nicolaidou, R. and Nielsen, J. and Nikiforov, A. and Nikolaenko, V. and Nikolic-Audit, I. and Nikolopoulos, K. and Nilsen, J.K. and Nilsson, P. and Ninomiya, Y. and Nisati, A. and Nisius, R. and Nobe, T. and Nomachi, M. and Nomidis, I. and Nooney, T. and Norberg, S. and Nordberg, M. and Norjoharuddeen, N. and Novgorodova, O. and Nowak, S. and Nozaki, M. and Nozka, L. and Ntekas, K. and Nurse, E. and Nuti, F. and O'grady, F. and O'Neil, D.C. and O'Rourke, A.A. and O'Shea, V. and Oakham, F.G. and Oberlack, H. and Obermann, T. and Ocariz, J. and Ochi, A. and Ochoa, I. and Ochoa-Ricoux, J.P. and Oda, S. and Odaka, S. and Ogren, H. and Oh, A. and Oh, S.H. and Ohm, C.C. and Ohman, H. and Oide, H. and Okawa, H. and Okumura, Y. and Okuyama, T. and Olariu, A. and Oleiro Seabra, L.F. and Olivares Pino, S.A. and Oliveira Damazio, D. and Olszewski, A. and Olszowska, J. and Onofre, A. and Onogi, K. and Onyisi, P.U.E. and Oreglia, M.J. and Oren, Y. and Orestano, D. and Orlando, N. and Orr, R.S. and Osculati, B. and Ospanov, R. and Otero y Garzon, G. and Otono, H. and Ouchrif, M. and Ould-Saada, F. and Ouraou, A. and Oussoren, K.P. and Ouyang, Q. and Owen, M. and Owen, R.E. and Ozcan, V.E. and Ozturk, N. and Pachal, K. and Pacheco Pages, A. and Pacheco Rodriguez, L. and Padilla Aranda, C. and Pagáčová, M. and Pagan Griso, S. and Paganini, M. and Paige, F. and Pais, P. and Pajchel, K. and Palacino, G. and Palazzo, S. and Palestini, S. and Palka, M. and Pallin, D. and St. Panagiotopoulou, E. and Pandini, C.E. and Panduro Vazquez, J.G. and Pani, P. and Panitkin, S. and Pantea, D. and Paolozzi, L. and Papadopoulou, Th.D. and Papageorgiou, K. and Paramonov, A. and Paredes Hernandez, D. and Parker, A.J. and Parker, M.A. and Parker, K.A. and Parodi, F. and Parsons, J.A. and Parzefall, U. and Pascuzzi, V.R. and Pasqualucci, E. and Passaggio, S. and Pastore, Fr. and Pásztor, G. and Pataraia, S. and Pater, J.R. and Pauly, T. and Pearce, J. and Pearson, B. and Pedersen, L.E. and Pedersen, M. and Pedraza Lopez, S. and Pedro, R. and Peleganchuk, S.V. and Penc, O. and Peng, C. and Peng, H. and Penwell, J. and Peralva, B.S. and Perego, M.M. and Perepelitsa, D.V. and Perez Codina, E. and Perini, L. and Pernegger, H. and Perrella, S. and Peschke, R. and Peshekhonov, V.D. and Peters, K. and Peters, R.F.Y. and Petersen, B.A. and Petersen, T.C. and Petit, E. and Petridis, A. and Petridou, C. and Petroff, P. and Petrolo, E. and Petrov, M. and Petrucci, F. and Pettersson, N.E. and Peyaud, A. and Pezoa, R. and Phillips, P.W. and Piacquadio, G. and Pianori, E. and Picazio, A. and Piccaro, E. and Piccinini, M. and Pickering, M.A. and Piegaia, R. and Pilcher, J.E. and Pilkington, A.D. and Pin, A.W.J. and Pinamonti, M. and Pinfold, J.L. and Pingel, A. and Pires, S. and Pirumov, H. and Pitt, M. and Plazak, L. and Pleier, M.-A. and Pleskot, V. and Plotnikova, E. and Plucinski, P. and Pluth, D. and Poettgen, R. and Poggioli, L. and Pohl, D. and Polesello, G. and Poley, A. and Policicchio, A. and Polifka, R. and Polini, A. and Pollard, C.S. and Polychronakos, V. and Pommès, K. and Pontecorvo, L. and Pope, B.G. and Popeneciu, G.A. and Poppleton, A. and Pospisil, S. and Potamianos, K. and Potrap, I.N. and Potter, C.J. and Potter, C.T. and Poulard, G. and Poveda, J. and Pozdnyakov, V. and Pozo Astigarraga, M.E. and Pralavorio, P. and Pranko, A. and Prell, S. and Price, D. and Price, L.E. and Primavera, M. and Prince, S. and Prokofiev, K. and Prokoshin, F. and Protopopescu, S. and Proudfoot, J. and Przybycien, M. and Puddu, D. and Purohit, M. and Puzo, P. and Qian, J. and Qin, G. and Qin, Y. and Quadt, A. and Quayle, W.B. and Queitsch-Maitland, M. and Quilty, D. and Raddum, S. and Radeka, V. and Radescu, V. and Radhakrishnan, S.K. and Radloff, P. and Rados, P. and Ragusa, F. and Rahal, G. and Raine, J.A. and Rajagopalan, S. and Rammensee, M. and Rangel-Smith, C. and Ratti, M.G. and Rauch, D.M. and Rauscher, F. and Rave, S. and Ravenscroft, T. and Ravinovich, I. and Raymond, M. and Read, A.L. and Readioff, N.P. and Reale, M. and Rebuzzi, D.M. and Redelbach, A. and Redlinger, G. and Reece, R. and Reed, R.G. and Reeves, K. and Rehnisch, L. and Reichert, J. and Reiss, A. and Rembser, C. and Ren, H. and Rescigno, M. and Resconi, S. and Rezanova, O.L. and Reznicek, P. and Rezvani, R. and Richter, R. and Richter, S. and Richter-Was, E. and Ricken, O. and Ridel, M. and Rieck, P. and Riegel, C.J. and Rieger, J. and Rifki, O. and Rijssenbeek, M. and Rimoldi, A. and Rimoldi, M. and Rinaldi, L. and Ristić, B. and Ritsch, E. and Riu, I. and Rizatdinova, F. and Rizvi, E. and Rizzi, C. and Robertson, S.H. and Robichaud-Veronneau, A. and Robinson, D. and Robinson, J.E.M. and Robson, A. and Roda, C. and Rodina, Y. and Rodriguez Perez, A. and Rodriguez Rodriguez, D. and Roe, S. and Rogan, C.S. and Røhne, O. and Roloff, J. and Romaniouk, A. and Romano, M. and Romano Saez, S.M. and Romero Adam, E. and Rompotis, N. and Ronzani, M. and Roos, L. and Ros, E. and Rosati, S. and Rosbach, K. and Rose, P. and Rosien, N.-A. and Rossetti, V. and Rossi, E. and Rossi, L.P. and Rosten, J.H.N. and Rosten, R. and Rotaru, M. and Roth, I. and Rothberg, J. and Rousseau, D. and Rozanov, A. and Rozen, Y. and Ruan, X. and Rubbo, F. and Rudolph, M.S. and Rühr, F. and Ruiz-Martinez, A. and Rurikova, Z. and Rusakovich, N.A. and Ruschke, A. and Russell, H.L. and Rutherfoord, J.P. and Ruthmann, N. and Ryabov, Y.F. and Rybar, M. and Rybkin, G. and Ryu, S. and Ryzhov, A. and Rzehorz, G.F. and Saavedra, A.F. and Sabato, G. and Sacerdoti, S. and Sadrozinski, H.F-W. and Sadykov, R. and Safai Tehrani, F. and Saha, P. and Sahinsoy, M. and Saimpert, M. and Saito, T. and Sakamoto, H. and Sakurai, Y. and Salamanna, G. and

Salamon, A. and Salazar Loyola, J.E. and Salek, D. and Sales De Bruin, P.H. and Salihagic, D. and Salnikov, A. and Salt, J. and Salvatore, D. and Salvatore, F. and Salvucci, A. and Salzburger, A. and Sammel, D. and Sampsonidis, D. and Sánchez, J. and Sanchez Martinez, V. and Sanchez Pineda, A. and Sandaker, H. and Sandbach, R.L. and Sandhoff, M. and Sandoval, C. and Sankey, D.P.C. and Sannino, M. and Sansoni, A. and Santoni, C. and Santonico, R. and Santos, H. and Santoyo Castillo, I. and Sapp, K. and Sapronov, A. and Saraiva, J.G. and Sarrazin, B. and Sasaki, O. and Sato, K. and Sauvan, E. and Savage, G. and Savard, P. and Savic, N. and Sawyer, C. and Sawyer, L. and Saxon, J. and Sbarra, C. and Sbrizzi, A. and Scanlon, T. and Scannicchio, D.A. and Scarcella, M. and Scarfone, V. and Schaarschmidt, J. and Schacht, P. and Schachtner, B.M. and Schaefer, D. and Schaefer, L. and Schaefer, R. and Schaeffer, J. and Schaepe, S. and Schaetzel, S. and Schäfer, U. and Schaffer, A.C. and Schaile, D. and Schamberger, R.D. and Scharf, V. and Schegelsky, V.A. and Scheirich, D. and Schernau, M. and Schiavi, C. and Schier, S. and Schillo, C. and Schioppa, M. and Schlenker, S. and Schmidt-Sommerfeld, K.R. and Schmieden, K. and Schmitt, C. and Schmitt, S. and Schmitz, S. and Schneider, B. and Schnoor, U. and Schoeffel, L. and Schoening, A. and Schoenrock, B.D. and Schopf, E. and Schott, M. and Schouwenberg, J.F.P. and Schovancova, J. and Schramm, S. and Schreyer, M. and Schuh, N. and Schulte, A. and Schultens, M.J. and Schultz-Coulon, H.-C. and Schulz, H. and Schumacher, M. and Schumm, B.A. and Schune, Ph. and Schwartzman, A. and Schwarz, T.A. and Schweiger, H. and Schwemling, Ph. and Schwienhorst, R. and Schwindling, J. and Schwindt, T. and Sciolla, G. and Scuri, F. and Scutti, F. and Searcy, J. and Seema, P. and Seidel, S.C. and Seiden, A. and Seifert, F. and Seixas, J.M. and Sekhniaidze, G. and Sekhon, K. and Sekula, S.J. and Seliverstov, D.M. and Semprini-Cesari, N. and Serfon, C. and Serin, L. and Serkin, L. and Sessa, M. and Seuster, R. and Severini, H. and Sfiligoj, T. and Sforza, F. and Sfyrla, A. and Shabalina, E. and Shaikh, N.W. and Shan, L.Y. and Shang, R. and Shank, J.T. and Shapiro, M. and Shatalov, P.B. and Shaw, K. and Shaw, S.M. and Shcherbakova, A. and Shehu, C.Y. and Sherwood, P. and Shi, L. and Shimizu, S. and Shimmin, C.O. and Shimojima, M. and Shirabe, S. and Shiyakova, M. and Shmeleva, A. and Shoaleh Saadi, D. and Shochet, M.J. and Shojaii, S. and Shope, D.R. and Shrestha, S. and Shulga, E. and Shupe, M.A. and Sicho, P. and Sickles, A.M. and Sidebo, P.E. and Sideras Haddad, E. and Sidiropoulou, O. and Sidorov, D. and Sidoti, A. and Siegert, F. and Sijacki, Dj. and Silva, J. and Silverstein, S.B. and Simak, V. and Simic, Lj. and Simion, S. and Simioni, E. and Simmons, B. and Simon, D. and Simon, M. and Sinervo, P. and Sinev, N.B. and Sioli, M. and Siragusa, G. and Sivoklokov, S.Yu. and Sjölin, J. and Skinner, M.B. and Skottowe, H.P. and Skubic, P. and Slater, M. and Slavicek, T. and Slawinska, M. and Sliwa, K. and Slovak, R. and Smakhtin, V. and Smart, B.H. and Smestad, L. and Smiesko, J. and Smirnov, S.Yu. and Smirnov, Y. and Smirnova, L.N. and Smirnova, O. and Smith, M.N.K. and Smith, R.W. and Smizanska, M. and Smolek, K. and Snesarev, A.A. and Snyder, I.M. and Snyder, S. and Sobie, R. and Socher, F. and Soffer, A. and Soh, D.A. and Sokhrannyi, G. and Solans Sanchez, C.A. and Solar, M. and Soldatov, E.Yu. and Soldevila, U. and Solodkov, A.A. and Soloshenko, A. and Solovyanov, O.V. and Solovyev, V. and Sommer, P. and Son, H. and Song, H.Y. and Sood, A. and Sopczak, A. and Sopko, V. and Sorin, V. and Sosa, D. and Sotiropoulou, C.L. and Soualah, R. and Soukharev, A.M. and South, D. and Sowden, B.C. and Spagnolo, S. and Spalla, M. and Spangenberg, M. and Spannowsky, M. and Spanò, F. and Sperlich, D. and Spettel, F. and Spighi, R. and Spigo, G. and Spiller, L.A. and Spousta, M. and St. Denis, R.D. and Stabile, A. and Stamen, R. and Stamm, S. and Stanecka, E. and Stanek, R.W. and Stanescu, C. and Stanescu-Bellu, M. and Stanitzki, M.M. and Stapnes, S. and Starchenko, E.A. and Stark, G.H. and Stark, J. and Staroba, P. and Starovoitov, P. and Stärz, S. and Staszewski, R. and Steinberg, P. and Stelzer, B. and Stelzer, H.J. and Stelzer-Chilton, O. and Stenzel, H. and Stewart, G.A. and Stillings, J.A. and Stockton, M.C. and Stoebe, M. and Stoicea, G. and Stolte, P. and Stonjek, S. and Stradling, A.R. and Straessner, A. and Stramaglia, M.E. and Strandberg, J. and Strandberg, S. and Strandlie, A. and Strauss, M. and Strizenec, P. and Ströhmer, R. and Strom, D.M. and Stroynowski, R. and Strubig, A. and Stucci, S.A. and Stugu, B. and Styles, N.A. and Su, D. and Su, J. and Suchek, S. and Sugaya, Y. and Suk, M. and Sulin, V.V. and Sultansoy, S. and Sumida, T. and Sun, S. and Sun, X. and Sundermann, J.E. and Suruliz, K. and Susinno, G. and Sutton, M.R. and Suzuki, S. and Svatos, M. and Swiatlowski, M. and Sykora, I. and Sykora, T. and Ta, D. and Taccini, C. and Tackmann, K. and Taenzer, J. and Taffard, A. and Tafirout, R. and Taiblum, N. and Takai, H. and Takashima, R. and Takeshita, T. and Takubo, Y. and Talby, M. and Talyshev, A.A. and Tan, K.G. and Tanaka, J. and Tanaka, M. and Tanaka, R. and Tanaka, S. and Tanioka, R. and Tannenwald, B.B. and Tapia Araya, S. and Tapprogge, S. and Tarem, S. and Tartarelli, G.F. and Tas, P. and Tasevsky, M. and Tashiro, T. and Tassi, E. and Tavares Delgado, A. and Tayalati, Y. and Taylor, A.C. and Taylor, G.N. and Taylor, P.T.E. and Taylor, W. and Teischinger, F.A. and Teixeira-Dias, P. and Temming, K.K. and Temple, D. and Ten Kate, H. and Teng, P.K. and Teoh, J.J. and Tepel, F. and Terada, S. and Terashi, K. and Terron, J. and Terzo, S. and Testa, M. and Teuscher, R.J. and Theveneaux-Pelzer, T. and Thomas, J.P. and Thomas-Wilsker, J. and Thompson, P.D. and Thompson, A.S. and Thomsen, L.A. and Thomson, E. and Tibbetts, M.J. and Ticse Torres, R.E. and Tikhomirov, V.O. and Tikhonov, Yu.A. and Timoshenko, S. and Tipton, P. and Tisserant, S. and Todome, K. and Todorov, T. and Todorova-Nova, S. and Tojo, J. and Tokár, S. and Tokushuku, K. and Tolley, E. and Tomlinson, L. and Tomoto, M. and Tompkins, L. and Toms, K. and Tong, B. and Tornambe, P. and Torrence, E. and Torres, H. and Torró Pastor, E. and Toth, J. and Touchard, F. and Tovey, D.R. and Trefzger, T. and Tricoli, A. and Trigger, I.M. and Trincaz-Duvoid, S. and Tripiana, M.F. and Trischuk, W. and Trocmé, B. and Trofymov, A. and Troncon, C. and Trottier-McDonald, M. and Trovatelli, M. and Truong, L. and Trzebinski, M. and Trzupek, A. and Tseng, J.C-L. and Tsiareshka, P.V. and Tsipolitis, G. and Tsirintanis, N. and Tsiskaridze, S. and Tsiskaridze, V. and Tskhadadze, E.G. and Tsui, K.M. and Tsukerman, I.I. and Tsulaia, V. and Tsuno, S. and Tsybychev, D. and Tu, Y. and Tudorache, A. and Tudorache, V. and Tuna, A.N. and Tupputi, S.A. and Turchikhin, S. and Turecek, D. and Turgeman, D. and Turra, R. and Tuts, P.M. and Tyndel, M. and Ucchielli, G. and Ueda, I. and Ughetto, M. and Ukegawa, F. and Unal, G. and Undrus, A. and Unel, G. and Ungaro, F.C. and Unno, Y. and Unverdorben, C. and Urban, J. and Urquijo, P. and Urrejola, P. and Usai, G. and Usui, J. and Vacavant, L. and Vacek, V. and Vachon, B. and Valderanis, C. and Valdes Santurio, E. and Valencic, N. and Valentinetti, S. and Valero, A. and Valery, L. and Valkar, S. and Valls Ferrer, J.A. and Van Den Wollenberg, W. and Van Der Deijl, P.C. and van der Graaf, H. and van Eldik, N. and van Gemmeren, P. and Van Nieuwkoop, J. and van Vulpen, I. and van Woerden, M.C. and Vanadia, M. and Vandelli, W. and Vanguri, R. and Vaniachine, A. and Vankov, P. and Vardanyan, G. and Vari, R. and Varnes, E.W. and Varol, T. and Varouchas, D. and Vartapetian, A. and Varvell, K.E. and Vasquez, J.G. and Vasquez, G.A. and Vazeille, F. and Vazquez Schroeder, T. and Veatch, J. and Veeraraghavan, V. and Veloce, L.M. and Veloso, F. and Veneziano, S. and Ventura, A. and Venturi, M. and Venturi, N. and Venturini, A. and Vercesi, V. and Verducci, M. and Verkerke, W. and Vermeulen, J.C. and Vest, A. and Vetterli, M.C. and Viazlo, O. and Vichou, I. and Vickey, T. and Vickey Boeriu, O.E. and Viehhauser, G.H.A. and Viel, S. and Vigani, L. and Villa, M. and Villaplana Perez, M. and Vilucchi, E. and Vincter, M.G. and Vinogradov, V.B. and Vittori, C. and Vivarelli, I. and Vlachos, S. and Vlasak, M. and Vogel, M. and Vokac, P. and Volpi, G. and Volpi, M. and von der Schmitt, H. and von Toerne, E. and Vorobel, V. and Vorobev, K. and Vos, M. and Voss, R. and Vossebeld, J.H. and Vranjes, N. and Vranjes Milosavljevic, M. and Vrba, V. and Vreeswijk, M. and Vuillermet, R. and Vukotic, I. and Vykydal, Z. and Wagner, P. and Wagner, W. and Wahlberg, H. and Wahrmund, S. and Wakabayashi, J. and Walder, J. and Walker, R. and Walkowiak, W. and Wallangen, V. and Wang, C. and Wang, C. and Wang, F. and Wang, H. and Wang, H. and Wang, J. and Wang, J. and Wang, K. and Wang, R. and Wang, S.M. and Wang, T. and Wang, T. and Wang, W. and Wanotayaroj, C. and Warburton, A. and Ward, C.P. and Wardrope, D.R. and Washbrook, A. and Watkins, P.M. and Watson, A.T. and Watson, M.F. and Watts, G. and Watts, S. and Waugh, B.M. and Webb, S. and Weber, M.S. and Weber, S.W. and Weber, S.A. and Webster, J.S. and Weidberg, A.R. and Weinert, B. and Weingarten, J. and Weiser, C. and Weits, H. and Wells, P.S. and Wenaus, T. and Wengler, T. and Wenig, S. and Wermes, N. and Werner, M. and Werner, M.D. and Werner, P. and Wessels, M. and Wetter, J. and Whalen, K. and Whallon, N.L. and Wharton, A.M. and White, A. and White, M.J. and White, R. and Whiteson, D. and Wickens, F.J. and Wiedenmann, W. and Wielers, M. and Wiglesworth, C. and Wiik-Fuchs, L.A.M. and Wildauer, A. and Wilk, F. and Wilkens, H.G. and Williams, H.H. and Williams, S. and Willis, C. and Willocq, S. and Wilson, J.A. and Wingerter-Seez, I. and Winklmeier, F. and Winston, O.J. and Winter, B.T. and Wittgen, M. and Wittkowski, J. and Wolf, T.M.H. and Wolter, M.W. and Wolters, H. and Worm, S.D. and Wosiek, B.K. and Wotschack, J. and Woudstra, M.J. and Wozniak, K.W. and Wu, M. and Wu, M. and Wu, S.L. and Wu, X. and Wu, Y. and Wyatt, T.R. and Wynne, B.M. and Xella, S. and Xu, D. and Xu, L. and Yabsley, B. and Yacoob, S. and Yamaguchi, D. and Yamaguchi, Y. and Yamamoto, A. and Yamamoto, S. and Yamanaka, T. and Yamauchi, K. and Yamazaki, Y. and Yan, Z. and Yang, H. and Yang, H. and Yang, Y. and Yang, Z. and Yao, W-M. and Yap, Y.C. and Yasu, Y. and Yatsenko, E. and Yau Wong, K.H. and Ye, J. and Ye, S. and Yeletskikh, I. and Yildirim, E. and Yorita, K. and Yoshida, R. and Yoshihara, K. and Young, C. and Young, C.J.S. and Youssef, S. and Yu, D.R. and Yu, J. and Yu, J.M. and Yu, J. and Yuan, L. and Yuen, S.P.Y. and Yusuff, I. and Zabinski, B. and Zaidan, R. and Zaitsev, A.M. and Zakharchuk, N. and Zalieckas, J. and Zaman, A. and Zambito, S. and Zanello, L. and Zanzi, D. and Zeitnitz, C. and Zeman, M. and Zemla, A. and Zeng, J.C. and Zeng, Q. and Zenin, O. and Ženiš, T. and Zerwas, D. and Zhang, D. and Zhang, F. and Zhang, G. and Zhang, H. and Zhang, J. and Zhang, L. and Zhang, M. and Zhang, R. and Zhang, R. and Zhang, X. and Zhang, Z. and Zhao, X. and Zhao, Y. and Zhao, Z. and Zhemchugov, A. and Zhong, J. and Zhou, B. and Zhou, C. and Zhou, L. and Zhou, L. and Zhou, M. and Zhou, N. and Zhu, C.G. and Zhu, H. and Zhu, J. and Zhu, Y. and Zhuang, X. and Zhukov, K. and Zibell, A. and Zieminska, D. and Zimine, N.I. and Zimmermann, C. and Zimmermann, S. and Zinonos, Z. and Zinser, M. and Ziolkowski, M. and Živković, L. and Zobernig, G. and Zoccoli, A. and zur Nedden, M. and Zwalinski, L. (2017) 'Measurement of W boson angular distributions in events with high transverse momentum jets at s= 8 TeV using the ATLAS detector.', Physics letters B., 765 . pp. 132-153.

Further information on publisher's website:

https://doi.org/10.1016/j.physletb.2016.12.005

Physics Letters B 765 (2017) 132–153

Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

Measurement of W boson angular distributions in events with high transverse momentum jets at $\sqrt{s} = 8$ TeV using the ATLAS detector

The ATLAS Collaboration *

ARTICLE INFO

Article history:
Received 23 September 2016
Received in revised form 30 November 2016
Accepted 2 December 2016
Available online 6 December 2016
Editor: W.-D. Schlatter

ABSTRACT

The W boson angular distribution in events with high transverse momentum jets is measured using data collected by the ATLAS experiment from proton–proton collisions at a centre-of-mass energy $\sqrt{s} = 8$ TeV at the Large Hadron Collider, corresponding to an integrated luminosity of 20.3 fb^{-1}. The focus is on the contributions to W + jets processes from real W emission, which is achieved by studying events where a muon is observed close to a high transverse momentum jet. At small angular separations, these contributions are expected to be large. Various theoretical models of this process are compared to the data in terms of the absolute cross-section and the angular distributions of the muon from the leptonic W decay.

1. Introduction

Precision measurements of Standard Model processes at the Large Hadron Collider (LHC) are crucial for probing the fundamental structure of the strong and electroweak interactions. The data sample corresponding to an integrated luminosity of 20.3 fb^{-1} collected by the ATLAS experiment from proton–proton (pp) collisions at a centre-of-mass energy $\sqrt{s} = 8$ TeV at the LHC allows detailed study of perturbative quantum chromodynamics (perturbative QCD, pQCD) and real and virtual electroweak (EW) corrections that impact measurements of W + jets production.

At high energies, real emission of weak bosons in dijet events can contribute significantly to inclusive W + jets measurements [1–5]. In leading-order (LO) calculations of W + 1-jet production, the W boson is balanced by the recoil hadronic jet, often referred to as *back-to-back* production. At next-to-leading order (NLO), QCD and EW corrections to W + 1-jet processes appear, both as real and virtual contributions. In the case of real W boson emission from an initial- or final-state quark, these contributions scale as $\mathcal{O}\left(\alpha \ln^2 p_{\mathrm{T},j}/m_W\right)$, where α is the gauge coupling of the unified EW theory, $p_{\mathrm{T},j}$ is the transverse momentum of the jet and m_W is the W boson mass, and have a collinear enhancement in the distribution of the angular distance between the W boson and the closest jet. The collinear enhancement arises from collinear and infrared divergences which would be present in the limit of vanishing W boson mass, but which are regulated by its finite mass. The procedures to correctly account for collinear parton radiation, such as massless gluon emission, are well known and led to the introduction of (Sudakov) parton showering of the initial- and final-state partons in Monte Carlo generators for QCD as well as quantum electrodynamics (QED) contributions. An analogous procedure is available for the emission of real W bosons [6]. The effect of real W boson emission can be probed by isolating events for which the cancellation between real and virtual corrections is incomplete, for example by studying the region of small angular separation between a jet and the W boson. This region also contains LO contributions from W + 2-jets, as well as corrections to that process, which must be included for accurate predictions.

Due to this complex mixture of W + 1-jet and W + 2-jet processes, and the relevant QCD and EW corrections to both, comparisons of measurements to predictions using multiple approaches for estimating those corrections are crucial. Comparisons of the measured angular spectra of the muon from the W boson with fixed-order predictions at NLO and next-to-next-to-leading-order (NNLO) and with programs with electroweak parton showers help in understanding the accuracy of these predictions.

The measurements presented here focus on events that contain a muon and a jet with transverse momentum $p_{\mathrm{T}} > 500$ GeV. In this kinematic regime, contributions to W + jets processes from real W boson emission are enhanced in the region of small angular separation between the W boson decay products and the closest jet. The angular separation is defined as the distance between the

* *E-mail address:* atlas.publications@cern.ch.

http://dx.doi.org/10.1016/j.physletb.2016.12.005
0370-2693/

muon and the closest jet, $\Delta R(\mu, \text{jet}) = \sqrt{(\Delta\phi)^2 + (\Delta\eta)^2}$,[1] hereafter referred to as ΔR. Measurements of this angular separation thus provide precision tests of pQCD and electroweak predictions for the rate and pattern of real W boson emission. Real W boson emission, also termed collinear W production, is the dominant process for events with $\Delta R < 2.4$, and thus $\Delta R < 2.4$ is referred to as the collinear region. The significance of this higher-order contribution at small ΔR is shown in Ref. [5]. For events with $\Delta R > 2.4$, the W boson is balanced by a hadronic recoil that may consist of one or more jets.

These measurements of the ΔR distribution probe a new region of phase space that has not been explicitly studied in detail. Measurements of $W+$jets production by both the ATLAS and CMS experiments often remove portions of the collinear region by requiring that the lepton (e or μ) is separated from any jet by an angular distance of $\Delta R > 0.5$ [7,8]. By relaxing this requirement to $\Delta R > 0.2$ and focusing on the distribution of angular separation between the muon and the closest jet in events with at least one very high p_{T} jet ($p_{\mathrm{T}} > 500$ GeV), it is possible to explicitly target real W emission with this measurement.

Collinear W production may constitute an important background in searches for beyond the Standard Model physics that involve Lorentz-boosted top quarks [9], either in rare topologies or at high energies. If the W decay products are collinear with one of the jets, the structure of that jet can begin to resemble that of the three-pronged structure of a boosted top quark. While the rate for collinear W production is suppressed relative to dijet production with no W emission, hadronic W decays can cause a large increase in the measured jet mass. The result is that W emission from quarks at very high p_{T} can yield single jets with definite substructure that resemble the boosted top-quark signals being searched for.

2. The ATLAS detector

The ATLAS detector [10,11] provides nearly full solid angle coverage around the pp collision point at the LHC.

The inner detector (ID) comprises a silicon pixel tracker closest to the beamline, a microstrip silicon tracker, and a straw-tube transition-radiation tracker at radii up to 108 cm. A thin solenoid surrounding the tracker provides a 2 T axial magnetic field enabling the measurement of charged-particle momenta. The overall ID acceptance spans the full azimuthal range in ϕ, and the range $|\eta| < 2.5$ for particles originating near the nominal LHC interaction region [12].

The electromagnetic (EM) and hadronic calorimeters are composed of multiple subdetectors spanning $|\eta| < 4.9$. The EM barrel calorimeter uses a liquid-argon (LAr) active medium, together with lead absorbers, and covers $|\eta| < 1.45$. In the region $|\eta| < 1.7$, the hadronic calorimeter is constructed from steel absorber and scintillator tiles and is separated into barrel ($|\eta| < 1.0$) and extended-barrel ($0.8 < |\eta| < 1.7$) sections. The endcap ($1.375 < |\eta| < 3.2$) and forward ($3.1 < |\eta| < 4.9$) regions are instrumented with LAr calorimeters for EM as well as hadronic energy measurements.

A muon spectrometer with three large air-core toroid magnet systems surrounds the calorimeters. The muon spectrometer measures the momentum of muons from their tracks, which are reconstructed with three layers of high-precision tracking chambers. These chambers provide coverage in the range $|\eta| < 2.7$, while dedicated fast chambers allow triggering in the region $|\eta| < 2.4$.

A three-level trigger system is used to record events for analysis. The different parts of the trigger system are referred to as the Level-1 trigger, the Level-2 trigger, and the Event Filter [13]. The Level-1 trigger is implemented in hardware and uses a subset of detector information to reduce the event rate to a design value of at most 75 kHz. The Level-1 trigger is followed by two software-based triggers, the Level-2 trigger and the Event Filter, which together reduce the event rate to a few hundred Hz.

3. Data and simulated samples

The measurement presented here is based on the entire 2012 pp dataset at a centre-of-mass energy of $\sqrt{s} = 8$ TeV. Events are required to meet baseline quality criteria during stable LHC running periods. These data quality criteria primarily reject data with significant contamination from detector noise or issues in the read-out [14] based upon individual assessments for each subdetector. The resulting dataset corresponds to an integrated luminosity of 20.3 fb^{-1}. The absolute luminosity scale is derived from beam-separation scans performed in November 2012. The uncertainty in the integrated luminosity is $\pm 1.9\%$ [15].

Simulated events from Monte Carlo (MC) generators are used for calculating the signal efficiency and estimating background in the signal region. The events are simulated using a GEANT4-based [16] full detector simulation [17]. In addition to the hard scatter, each event is overlaid with a number of additional pp collisions (pile-up) extracted from the distribution of the average number of pp interactions per bunch crossing μ observed in data. These additional pp collisions are generated with PYTHIA v8.160 [18] using the ATLAS A2 set of tuned parameters (A2 tune) [19] and the MSTW2008LO parton distribution function (PDF) set [20].

Events containing $W+$jets are generated with ALPGEN 2.14 [21], which implements MLM matching [22] of the matrix element calculation with parton showering. The W boson is produced as part of the matrix element calculations, allowing simulation of both collinear and back-to-back $W+$jets production. In the latter, the W boson is balanced by the hadronic recoil system. The matrix elements provided by ALPGEN are configured to allow up to five partons in the final state in addition to the W boson, including heavy-flavour production as well. The generator is interfaced with PYTHIA v6.427 [23] for parton showering and fragmentation. The CTEQ6L1 PDF set [24] is used. A K-factor is applied to these samples to correct the normalisation to a NNLO pQCD inclusive cross-section calculated with FEWZ [25] and the MSTW2008NNLO PDF set. A sample of events is also generated with PYTHIA v8.210 and using the CT10 NLO PDF set [26] in which W boson radiation can be produced via a weak parton shower.

Dijet events are generated with PYTHIA v8.165. Top-quark pair production is simulated with POWHEG-r2129 [27–30] interfaced with PYTHIA v6.426 with the P2011C [31] tune for parton showering and fragmentation. Diboson production is simulated with MC@NLO v4.07 [32]. Additional samples of diboson production are generated using SHERPA v1.43 [33] and these are used to estimate theoretical uncertainties in the diboson background estimation. The above samples are all generated using the CT10 NLO PDF set. Events containing $Z+$jets are generated with ALPGEN using the same configuration as the $W+$jets simulation above. Single top-quark production is a negligible background for this analysis and is not included.

All samples are normalised to their calculated inclusive cross-sections. However, for the $W+$jets, dijets, $t\bar{t}$ and $Z+$jets samples, there is an additional correction applied to the normalisation, derived from the comparison of data and Monte Carlo simulations in

[1] ATLAS uses a right-handed coordinate system with its origin at the nominal interaction point (IP) in the centre of the detector and the z-axis along the beam pipe. The x-axis points from the IP to the centre of the LHC ring, and the y-axis points upward. Cylindrical coordinates (r, ϕ) are used in the transverse plane, ϕ being the azimuthal angle around the z-axis. The pseudorapidity is defined in terms of the polar angle θ as $\eta = -\ln\tan(\theta/2)$.

the signal region and control regions. The process of deriving this correction is explained in detail in Section 4.

4. Object and event selections

4.1. Baseline event selection

The topology of collinear W production involves two back-to-back high-p_{T} jets, one of which emits a nearby W boson. Events are required to contain at least one jet with $p_{\mathrm{T}} > 500$ GeV, as this is found to be sufficient to probe the kinematic region of interest. The probability of a collinear W emission from such a jet is estimated by PYTHIA v8.210 to be 0.15%. Over half of the production of $W+$jets in the phase space probed in this measurement is in the collinear region. A requirement for a second high-p_{T} jet is not applied. Although both jets initially recoil from each other and have similar p_{T}, the jet that emits the collinear W boson can lose a significant amount of energy to the muon and neutrino, neither of which are reconstructed as part of the jet energy. Requiring a second high-p_{T} jet would impose an implicit maximum on the energy carried by the W boson and its decay products.

The analysis focuses on the leptonic decays of W bosons to muons in order to ensure a high reconstruction purity, and thus events are required to have exactly one muon. Events that contain an electron are rejected, which reduces the background by removing mixed-flavour dileptonic (electron plus muon) $t\bar{t}$ decays. Control regions are used to establish the normalisation of MC simulations of several background processes. These regions are defined by inverting various selection criteria used in the final measurement.

To reject non-collision background [34], events are required to contain at least one primary vertex consistent with the beam-interaction region, reconstructed from at least two tracks each with $p_{\mathrm{T}}^{\mathrm{track}} > 400$ MeV. The primary hard-scatter vertex is defined as the vertex with the highest $\sum(p_{\mathrm{T}}^{\mathrm{track}})^2$. To reject rare events contaminated by spurious signals in the detector, all anti-k_t [35,36] jets with radius parameter $R = 0.4$ and $p_{\mathrm{T}}^{\mathrm{jet}} > 20$ GeV (see below) are required to satisfy the loosest jet-quality requirements discussed in Ref. [34]. These criteria are designed to reject non-collision background and significant transient noise in the calorimeters while maintaining an efficiency for good-quality events greater than 99.8% with as high a rejection of contaminated events as possible. In particular, this selection is very efficient in rejecting events that contain fake jets due to calorimeter noise.

4.2. Trigger selection

Events used in this analysis are selected by requiring that they pass at least one of two single-muon triggers [37]. The first trigger requires an isolated muon with $p_{\mathrm{T}} > 24$ GeV and the second trigger requires a muon with $p_{\mathrm{T}} > 36$ GeV with no isolation criteria applied. The track-based isolation used in the trigger requires that the scalar sum of the p_{T} of all tracks within a cone of radius $\Delta R = 0.2$ around the muon is less than 12% of the muon p_{T}.

4.3. Object reconstruction

Muons are reconstructed by combining tracks in the ID with tracks in the muon spectrometer [38]. They are required to have $p_{\mathrm{T}} > 25$ GeV and $|\eta| < 2.4$. To reduce contamination from semileptonic b-decays, in-flight pion and kaon decays and cosmic muons, their longitudinal impact parameter with respect to the primary vertex z_0 must satisfy $|z_0| \sin\theta < 0.5$ mm and their transverse impact parameter with respect to the primary vertex d_0 must satisfy $|d_0|/\sigma(d_0) < 3$. The selected offline reconstructed muon must also match the online muon that passed the trigger.

Jets are built using the anti-k_t algorithm with a radius parameter of $R = 0.4$ from locally calibrated three-dimensional topological energy clusters [39]. The resulting jets are required to have $p_{\mathrm{T}} > 100$ GeV and $|\eta| < 2.1$.

The number of b-tagged jets for a given event is calculated using the MV1 tagger [40] on jets built using the anti-k_t algorithm with $R = 0.4$. The jets considered for b-tagging have $p_{\mathrm{T}} > 25$ GeV and are reconstructed within $|\eta| < 2.1$. The MV1 tagger is configured to have a b-tagging efficiency of 70% in semileptonic $t\bar{t}$ events.

Electrons are reconstructed from a combination of a calorimeter energy cluster and a matched ID track [41,42]. They must meet a set of identification criteria (the so-called *medium* criteria of Ref. [41]). They are also required to have $p_{\mathrm{T}} > 20$ GeV and $|\eta| < 2.47$, excluding the transition region between the barrel and the endcap calorimeters ($1.37 < |\eta| < 1.52$). To reduce the contamination from semileptonic b-decays and misidentification, the same impact parameter requirements used for muons are applied along with an isolation requirement. This isolation is track-based and requires that the scalar sum of the p_{T} of all tracks in a cone of radius $\Delta R = 0.2$ around the electron be less than 15% of the electron p_{T}.

4.4. Measurement selection

To select the $W+$jets signal, events are required to contain at least one jet with $p_{\mathrm{T}} > 500$ GeV, exactly one muon, no b-tagged jets, a primary vertex and no electrons. Any additional jets with $p_{\mathrm{T}} > 100$ GeV are included in the analysis. The leading jet, defined as the jet with the highest p_{T}, is not necessarily the one closest to the muon. The ΔR distance is always measured with respect to the closest jet. The muon is required to be isolated using both track-based and calorimeter-based isolation criteria. The track isolation requires that the scalar sum of the p_{T} of all tracks in a cone of radius $\Delta R = 0.2$ around the muon be less than 10% of the muon p_{T}. The calorimeter isolation requires that the scalar sum of the p_{T} in all calorimeter cells in a cone of radius $\Delta R = 0.2$ around the muon be less than 40% of the muon p_{T}. Applying these isolation criteria significantly reduces the background from dijet events, where muons mostly originate from heavy-flavour or in-flight decays and are non-isolated. The b-tag veto also reduces the background from $t\bar{t}$, which generates two b-quarks in their decay, by over 80%, while only 10% of the $W+$jets signal is rejected. Requirements on missing transverse momentum were not found to improve the signal selection or background rejection. The efficiency of the isolation requirement was studied both in simulated samples and in situ using data events containing high-p_{T} top quarks, and the results from the two studies were in agreement. However, in the extremely collinear region, where the distance between the muon and the closest jet is $\Delta R < 0.2$, the limited size of the event sample did not allow the same conclusion. As a result, events where $\Delta R < 0.2$ are also excluded. This causes approximately 2% of the $W+$jets signal to be rejected.

4.5. Control region definitions and background estimation

For the final state with at least one high-p_{T} jet and a single muon, the dominant background processes that contribute to the signal region are dijets, $t\bar{t}$ and $Z+$jets. In addition, there is a small background contribution from diboson production. These are all modelled using the simulated samples described in Section 3.

For each of the three main background processes, a control region utilising an event selection different from the signal region is defined such that most of the events in this control region are from

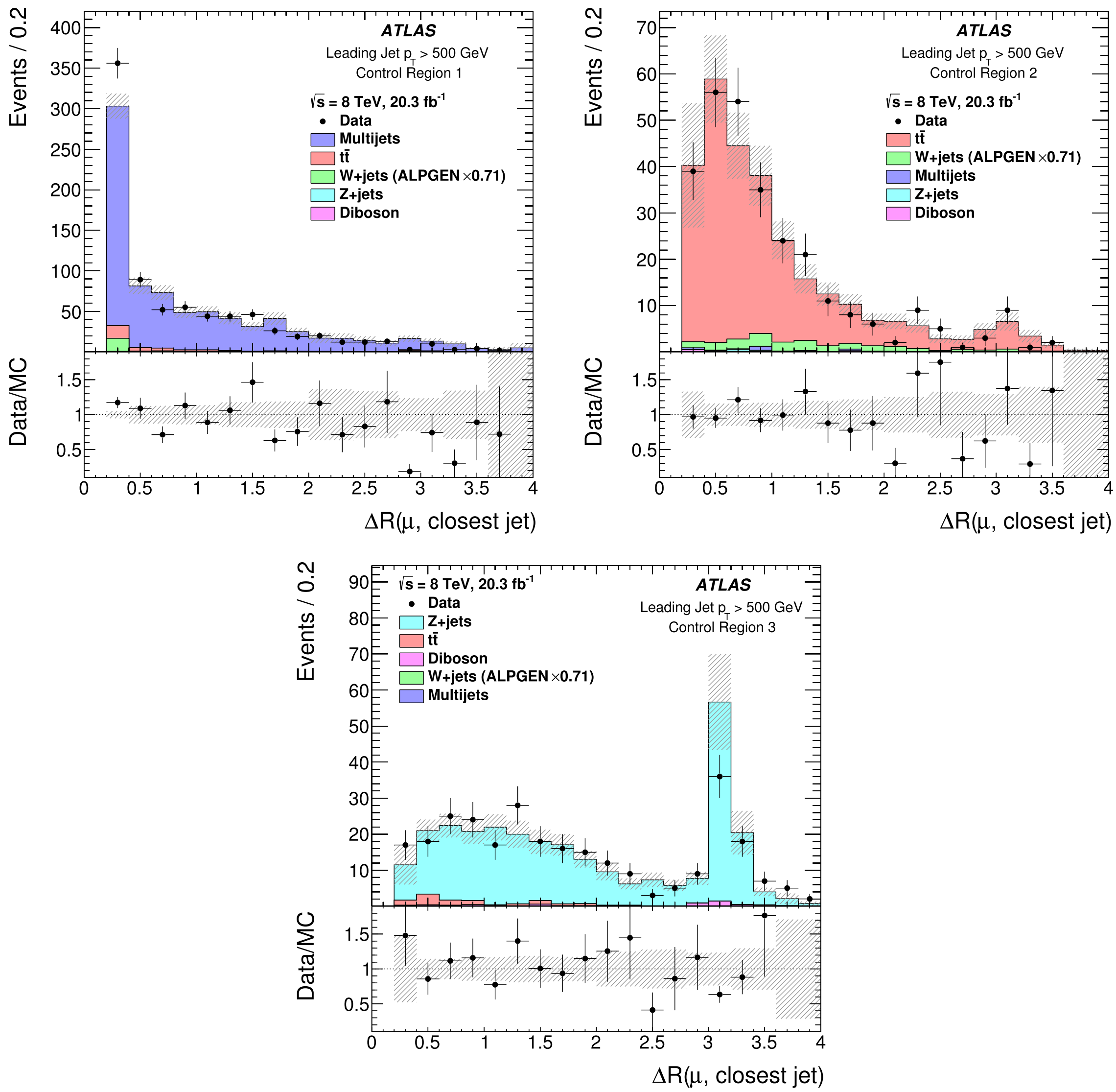


Fig. 1. Comparisons between data and the predicted distribution from MC simulations of the angular separation between the muon and the closest jet in Control Region 1 (left), Control Region 2 (right) and Control Region 3 (bottom). The lower panels show the ratio of data to the predicted distribution. The error bars correspond to the statistical uncertainty and the shaded error band corresponds to the systematic uncertainties. The dijet, $t\bar{t}$ and $Z+$jets backgrounds have been scaled according to their respective control regions. The $W+$jets signal has been scaled by 0.71.

the chosen background. Control Region 1 is enriched in dijets, with a 93% purity of dijet events, by applying the inverse of the signal region isolation selection. It uses events that pass the muon trigger without an isolation requirement and requires the muon to have $p_{\mathrm{T}} > 38$ GeV, as events with a non-isolated muon of lower p_{T} are mostly rejected by the trigger, together with a distance $\Delta R > 0.2$ between the muon and the closest jet. Control Region 2 is enriched in $t\bar{t}$, with 91% of events originating from $t\bar{t}$ production, by requiring at least two b-tagged jets. Control Region 3 is enriched in $Z+$jets, which constitute 94% of events in this region, by using events with exactly two muons, with both muons passing the signal region isolation. It is further required that the dimuon invariant mass in Control Region 3 satisfies 60 GeV $< m_{\mu\mu} <$ 120 GeV. In this case, the muon with the higher p_{T} is chosen to define ΔR.

Using data from these control regions and the signal region, a scale factor is derived for each main background process and the $W+$jets signal to correct the normalisation of the MC sample to that observed in data. To ensure the scale factor is not affected by contamination from other backgrounds and the $W+$jets signal, it is necessary to subtract the MC prediction for the contamination from the control region data. As there is a circular dependency in using scaled MC predictions to derive new scalings, an iterative approach is applied. First, the scale factors are derived with the contamination subtracted using the uncorrected normalisations. Then the normalisations are updated with the scale factor corrections and the procedure to derive them is repeated. Since the contamination in each of the regions is quite small, the scale factors converge very rapidly. The dijet sample is scaled by 1.134 ± 0.054, the $t\bar{t}$ sample is scaled by 0.861 ± 0.061, the $Z+$jets sample is scaled by 0.705 ± 0.052 and the $W+$jets sample is scaled by 0.711 ± 0.016. These uncertainties in the scale factors are due to the statistical uncertainty of the data and MC samples and are part of the overall uncertainties in the measurement detailed in Section 6. However, the uncertainty in the $W+$jets scale factor has no effect on the results of the measurement. After the scale factors are applied, the MC predictions and observed distributions of the distance between the muon and the closest jet for each control region are shown in Fig. 1. The systematic uncertainties shown in Fig. 1 correspond to those described in Section 6.

Table 1
The systematic uncertainties in the cross-section measurement. Multiple independent components have been combined into groups of systematic uncertainties.

Systematic Source	$0.2 < \Delta R < 2.4$	$\Delta R > 2.4$	Inclusive
Scaling of dijets to data	0.4%	0.1%	0.3%
Scaling of $t\bar{t}$ to data	0.6%	0.2%	0.5%
Scaling of $Z+$jets to data	0.6%	0.3%	0.5%
Jet energy scale	4.6%	5.8%	5.0%
b-tagging efficiency	3.7%	1.2%	2.9%
Data/MC disagreement for dijets	0.9%	0.6%	0.8%
Data/MC disagreement for $t\bar{t}$	1.2%	0.4%	1.0%
Data/MC disagreement for $Z+$jets	0.6%	1.5%	0.9%
Diboson background estimate	2.2%	0.1%	1.5%
Unfolding dependence on prior	1.1%	1.8%	1.3%
Muon momentum scale and resolution	0.0%	0.1%	0.1%
Muon reconstruction efficiency	0.4%	0.4%	0.4%
Muon trigger efficiency	2.0%	1.9%	1.9%
Jet energy resolution	0.6%	0.8%	0.6%
MC background statistical	2.4%	1.8%	2.3%
MC response statistical	1.7%	2.2%	1.9%
Total systematic (excluding luminosity)	7.6%	7.4%	7.3%
Luminosity	1.9%	2.0%	2.0%
Data statistical	2.7%	3.6%	2.2%

5. Definition of observable and correction for detector effects

The estimated background is subtracted from the data in the signal region and the resultant distribution of the distance ΔR between the muon and the closest jet is unfolded using an iterative Bayesian technique [43] to correct for detector effects including both the efficiency of the selection criteria and the resolution of the angular separation between the muon and the nearest jet, where the former effect is dominant. This technique is implemented within the RooUnfold framework [44]. A response matrix derived from MC simulation is used to correct the distribution from detector-level to particle-level. The particle-level prediction from MC simulation is used as an initial prior during the first iteration of the unfolding. Subsequent iterations use the previous iteration's unfolded distribution as a new prior. A single iteration step is used, as this was found to be the optimal choice that minimised the combination of statistical fluctuation and the bias introduced by the prior of unfolded results.

The detector response and the combined efficiency of the trigger, reconstruction and the analysis selection for the $W+$jets signal is obtained from MC simulation. The fiducial selection applied to MC simulation is similar to the kinematic selection of the analysis. Particle-level jets, built from stable final-state particles (defined as those with a proper lifetime τ corresponding to $c\tau \geq 10$ mm [45]) excluding muons and neutrinos, must satisfy $p_{\mathrm{T}} > 100$ GeV and $|\eta| < 2.1$. Events are required to have at least one particle-level jet with $p_{\mathrm{T}} > 500$ GeV and a particle-level muon with a dressed[2] $p_{\mathrm{T}} > 25$ GeV and $|\eta| < 2.4$. No requirements on promptness are applied to the muons or the dressing photons. Any additional muons that pass these requirements cause the event to be rejected. Events where the distance between the muon and the closest jet $\Delta R < 0.2$ are also rejected. Unlike the analysis selection, there are no requirements on b-jets or electrons for the fiducial selection.

The unfolding to the fiducial region also corrects for events that do not pass the particle-level selection, but pass the detector-level selection. Events in the fiducial signal region that arise from $W \to \tau\nu$ are also removed so that the cross-section is quoted exclusively for the muon decay channel.

[2] Photons that are contained in a cone of size $\Delta R = 0.1$ around the muon are summed and included as part of the muon energy.

6. Systematic uncertainties

The dominant systematic uncertainties in the cross-section measurement arise from the uncertainties in the jet energy scale and the b-tagging efficiency. For each systematic uncertainty, the selection criteria are re-applied, the control region normalisations are reassessed, and the unfolding procedure is repeated with the quantity under consideration varied by ± 1 standard deviation. The average of the up and down variations of the final cross-section measurement are summed in quadrature, as the variations are independent and not correlated. This sum is then used as the full systematic uncertainty. The systematic uncertainties in the measurement, grouped by source, are summarised in Table 1 for the inclusive cross-section, the collinear region ($0.2 < \Delta R < 2.4$) and the back-to-back region ($\Delta R > 2.4$).

Since the dijet, $t\bar{t}$ and $Z+$jets simulated samples are scaled to data in their respective control regions, there is a systematic uncertainty in the scaling that arises from the statistical uncertainty in the data and the MC simulations in these control regions. As the control region for dijets does not have the same kinematic selection as the signal region, there could be some bias due to mismodelling of the dijet kinematics in the simulated sample. An uncertainty accounting for this is derived by varying the kinematic selection of the control region.

The uncertainty in the jet energy scale comprises 17 independent components [46]. Six of these are derived from various in situ analyses and two are related to the η intercalibration of the jets. There are also four components that account for the mismodelling of the p_{T} response with respect to pile-up and three topology components that account for the dependence of the p_{T}-response uncertainty on the relative fractions of jets initiated by light quarks, gluons and b-quarks.

To correct the b-tagging efficiency in simulation to that observed in data, scale factors derived from in situ analyses are applied to the simulated samples [47,48]. These have associated uncertainties. The uncertainties for b-, c- and τ-jets are assessed independently from those for light jets and the uncertainties in the efficiency scale factors are fully anti-correlated with those in the inefficiency scale factors.

In each control region, any disagreement between the ΔR distributions for data and MC simulations is taken as a systematic uncertainty for the ΔR prediction from that specific background in the signal region. This introduces an additional data-driven sys-

Table 2
The number of events in the signal region observed in data, along with the composition of these events as predicted by MC simulation, split by the distance between the muon and the closest jet. The dijet, $t\bar{t}$ and $Z+$jets backgrounds have been scaled according to their respective control regions. The $W+$jets signal has been scaled by 0.71.

Process	$0.2 < \Delta R < 2.4$	$\Delta R > 2.4$	Inclusive
Dijets	5%	2%	4%
$t\bar{t}$	7%	2%	5%
$Z+$jets	6%	4%	5%
Dibosons	2%	4%	3%
$W+$jets	80%	88%	82%
Data	1907	833	2740

tematic uncertainty to the dijet, $t\bar{t}$ and $Z+$jets estimates for the ΔR distribution. Since the diboson background prediction is not constrained by data from a control region, an alternative prediction is obtained from a different simulated sample generated using SHERPA. The difference between these two predictions is taken as an uncertainty in the diboson background estimate.

The systematic uncertainty due to the dependence of the unfolding on the prior signal distribution, as obtained from MC simulations, is evaluated through a data-driven closure test. The simulated signal sample is reweighted at particle-level such that the distribution of the fully simulated detector-level ΔR more closely matches the observed data. This reweighted simulated detector-level distribution is then unfolded and compared with the reweighted particle-level distribution. Differences observed in this comparison are taken as a systematic uncertainty in the unfolding. The uncertainty due to the dependence on the number of unfolding iteration steps was negligible.

Other smaller uncertainty contributions arise from the uncertainty in the integrated luminosity, the uncertainties in the muon momentum scale and resolution, muon reconstruction efficiency and trigger efficiency and the uncertainties in the jet energy resolution [49]. Uncertainties in the electron energy scale and resolution were evaluated but found to be negligible.

7. Results

The number of events in the signal region observed in data is listed in Table 2, along with the composition of these events as predicted by MC simulation. Numbers are given for the collinear region ($0.2 < \Delta R < 2.4$), the back-to-back region ($\Delta R > 2.4$), and the inclusive sample. The uncorrected distributions of the reconstructed distance between the muon and the closest jet observed in data and predicted by MC simulations are shown in Fig. 2 for the signal region. In general the distributions agree within the uncertainties, except around $\Delta R = 2.8$ where there is a deficit and around the most collinear region of $\Delta R < 0.5$ where there is a slight excess in the prediction from MC simulations.

7.1. Differential cross-section measurement

The differential cross-section of $W \to \mu\nu$ as a function of $\Delta R(\mu, \text{closest jet})$, obtained from the unfolded data of the signal region, is shown in Fig. 3. The measured total cross-sections for the inclusive case, in the collinear region and the back-to-back region are also listed in Tables 3–5.

The measurements are compared to several theory predictions. The ALPGEN+PYTHIA6 $W+$jets calculation and the normalisation K-factor used for this prediction are described in Section 3 and the quoted uncertainties are the statistical uncertainties. The $W+j$ and $jj+$weak shower calculation provided by PYTHIA v8.210, described in Section 3, is shown as well. In this case, the W boson

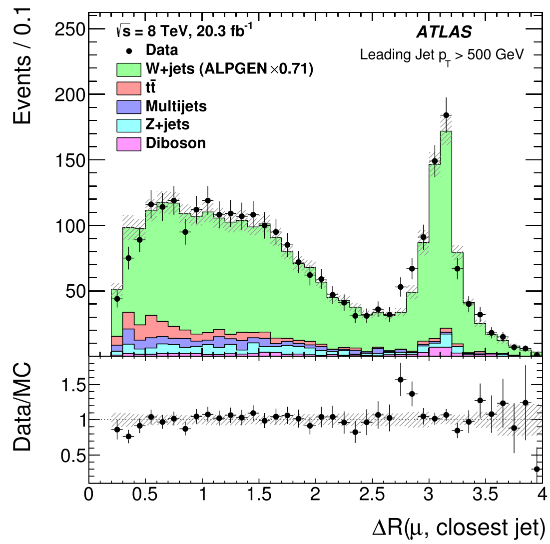


Fig. 2. Predicted distribution from MC simulation of the angular separation between the muon and the closest jet and the observed distribution from data for the signal region. The lower panel shows the ratio of data to the predicted distribution. The error bars correspond to the statistical uncertainty and the shaded error band corresponds to the systematic uncertainties. The dijet, $t\bar{t}$ and $Z+$jets backgrounds have been scaled according to their respective control regions. The $W+$jets signal has been scaled by 0.71.

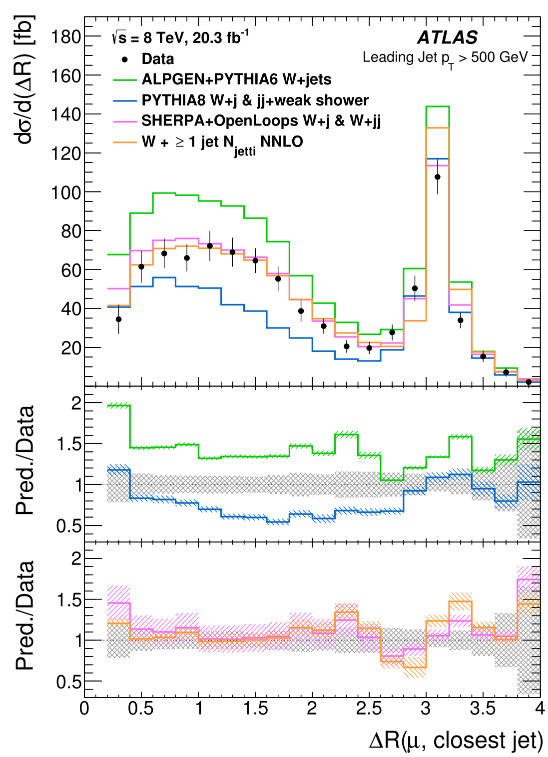


Fig. 3. Unfolded distribution from background-subtracted data of the angular separation between the muon and the closest jet in the signal region along with several predictions from theory calculations. The lower panels show the ratio of the theory predictions to the unfolded data. The error bars in the upper panel and the grey shaded error bands in the lower ratio panels are the sum of the statistical and systematic uncertainties in the measurement. The shaded error band on the ALPGEN+PYTHIA6 calculation is statistical uncertainty, the band on the PYTHIA8 calculation is statistical and PDF uncertainties and those on the SHERPA+OpenLoops and the $W+\geq 1$ jet N_{jetti} NNLO calculations are scale uncertainties.

Table 3
Cross-section for $W(\to \mu\nu) + \geq 1$ jet as measured in data and as predicted by various calculations.

Process	$\sigma\,(W(\to \mu\nu) + \geq 1 \text{ jet})$ [fb]
Data ($\sqrt{s} = 8$ TeV, 20.3 fb^{-1})	169.2 ± 3.7 (stat.) ± 12.3 (syst.) ± 3.3 (lumi.)
ALPGEN+PYTHIA6 W + jets	236.6 ± 1.1 (stat.)
PYTHIA8 $W + j$ & jj + weak shower	134.8 ± 0.9 (stat.) ± 7.3 (pdf)
SHERPA+OpenLoops $W + j$ & $W + jj$	183 ± 25 (scale)
$W + \geq 1$ jet N_{jetti} NNLO	181 ± 14 (scale)

Table 4
Cross-section for $W(\to \mu\nu) + \geq 1$ jet in the collinear ($0.2 < \Delta R < 2.4$) region as measured in data and as predicted by various calculations.

Process	$\sigma\,(W(\to \mu\nu) + \geq 1 \text{ jet},\ 0.2 < \Delta R < 2.4)$ [fb]
Data ($\sqrt{s} = 8$ TeV, 20.3 fb^{-1})	116.2 ± 3.2 (stat.) ± 8.8 (syst.) ± 2.3 (lumi.)
ALPGEN+PYTHIA6 W + jets	167.1 ± 0.9 (stat.)
PYTHIA8 $W + j$ & jj + weak shower	83.4 ± 0.7 (stat.) ± 4.4 (pdf)
SHERPA+OpenLoops $W + j$ & $W + jj$	128 ± 20 (scale)
$W + \geq 1$ jet N_{jetti} NNLO	123 ± 9 (scale)

Table 5
Cross-section for $W(\to \mu\nu) + \geq 1$ jet in the back-to-back ($\Delta R > 2.4$) region as measured in data and as predicted by various calculations.

Process	$\sigma\,(W(\to \mu\nu) + \geq 1 \text{ jet},\ \Delta R > 2.4)$ [fb]
Data ($\sqrt{s} = 8$ TeV, 20.3 fb^{-1})	53.0 ± 1.9 (stat.) ± 3.9 (syst.) ± 1.0 (lumi.)
ALPGEN+PYTHIA6 W + jets	69.5 ± 0.6 (stat.)
PYTHIA8 $W + j$ & jj + weak shower	51.4 ± 0.6 (stat.) ± 2.9 (pdf)
SHERPA+OpenLoops $W + j$ & $W + jj$	55 ± 5 (scale)
$W + \geq 1$ jet N_{jetti} NNLO	58 ± 5 (scale)

can either be produced by the matrix elements of the $W + 1$-jet final state or be emitted as electroweak final-state radiation in the parton shower of a dijet event. The quoted uncertainties are the sums of the statistical uncertainties and the uncertainties from the CT10 NLO PDF set. The data are compared to the nominal predictions from ALPGEN+PYTHIA6 and PYTHIA8.

The SHERPA+OpenLoops $W + j$ and $W + jj$ calculation incorporates NLO QCD and NLO EW corrections to both of these processes [50–55]. In the high-p_{T} regime of the analysis, the NLO EW corrections can have significant effects – up to 20% – across the ΔR distribution. A second-jet veto is applied to the $W + j$ NLO predictions and this is then combined with the $W + jj$ NLO predictions. The SHERPA+OpenLoops calculation also includes contributions from off-shell boson production and the sub-leading Born-level contributions ($O(\alpha^3)$ for $W + j$ and $O(\alpha_S\alpha^3)$ for $W + jj$). The NNPDF2.3QED NLO PDF [56] is used. Both the renormalisation and factorisation scales are set to $\mu_0 = 1/2\left(\sqrt{m_{\mu\nu}^2 + (p_{\text{T}}^{\mu\nu})^2} + \Sigma_i p_{\text{T}}^{J_i} + \Sigma_i p_{\text{T}}^{\gamma_i}\right)$, where $m_{\mu\nu}$ and $p_{\text{T}}^{\mu\nu}$ are the mass and transverse momentum of the total four-momentum of the dressed muon and neutrino, $p_{\text{T}}^{J_i}$ is the transverse momentum of each jet, and $p_{\text{T}}^{\gamma_i}$ is the transverse momentum of each photon not used for dressing. The quoted uncertainties are the scale uncertainties, where the renormalisation scale and the factorisation scale have been varied independently by a factor of two.

An NNLO QCD calculation, which includes up to $O(\alpha_S^3)$, for the angular separation between the lepton from the W boson decay and the nearest jet in W + jets events has recently become available [57,58]. This calculation, obtained from Ref. [5], is denoted '$W + \geq 1$ jet N_{jetti} NNLO' here. It uses a new technique based on N-jettiness [59] to split the phase space for the real emission corrections. It relies on the theoretical formalism provided in soft-collinear effective theory. The calculation uses the CT14 NNLO PDF [60] and $\mu_0 = \sqrt{m_{\ell\nu}^2 + \Sigma_i (p_{\text{T}}^{J_i})^2}$, where $m_{\ell\nu}$ is the invariant mass of the lepton and neutrino and $p_{\text{T}}^{J_i}$ is the transverse momentum of each jet, is used for both the renormalisation and factorisation scale. The quoted uncertainties are the scale uncertainties, where the renormalisation scale and the factorisation scale have been varied independently by a factor of two. The resulting partonic final state is clustered using the anti-k_t jet algorithm with $R = 0.4$. No non-perturbative corrections are applied. The selections used in the calculation,

$$p_{\text{T}}^{\text{jet}} > 100\ \text{GeV}, \quad |\eta^{\text{jet}}| < 2.1, \quad p_{\text{T}}^{\text{leading jet}} > 500\ \text{GeV},$$
$$p_{\text{T}}^{\ell} > 25\ \text{GeV}, \quad |\eta^{\ell}| < 2.5, \tag{1}$$

are the same as the ones used for the measurement except for the muon pseudorapidity ($|\eta| < 2.5$ instead of $|\eta| < 2.4$). The effect of this difference in muon pseudorapidity is evaluated using the ALPGEN+PYTHIA6 W + jets sample and a correction factor accounting for this, which is less than 4% across the entire distribution, is applied. The calculated cross-sections obtained at LO, NLO and NNLO without the muon pseudorapidity correction are shown in Table 6. The scale uncertainty decreases from ∼±20% at NLO to +3%/−7% at NNLO.

Table 6
Fiducial W + jets cross-sections for the selection criteria of (1) at LO, NLO and NNLO in QCD from Ref. [5]. The uncertainties shown are the scale uncertainties.

	σ_{LO} [fb]	σ_{NLO} [fb]	σ_{NNLO} [fb]
8 TeV	57^{+13}_{-10}	160^{+35}_{-27}	187^{+5}_{-12}

The comparison of the data to ALPGEN+PYTHIA6 in Fig. 3 shows good shape agreement to within uncertainties, except at very low ΔR, but ALPGEN+PYTHIA6 predicts a significantly higher integrated cross-section. The comparison to PYTHIA8 at high ΔR, where it is dominated by back-to-back W + jets production in

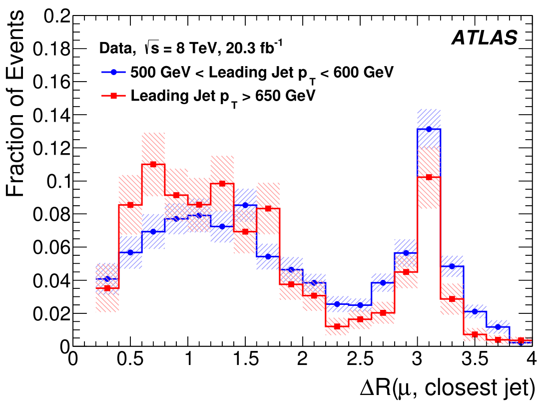


Fig. 4. Unfolded distribution from background-subtracted data of the angular separation between the muon and the closest jet for events with 500 GeV $< p_{\mathrm{T}}^{\text{leading jet}} <$ 600 GeV (blue circles) and $p_{\mathrm{T}}^{\text{leading jet}} >$ 650 GeV (red squares) from the signal region. Distributions are normalised to unity. The shaded error band on the unfolded measurement corresponds to the sum of the statistical and systematic uncertainties. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

which the W boson is balanced by the hadronic recoil system, shows much better agreement. At smaller ΔR, where the collinear process dominates, neither the shape nor the overall cross-section agree. The comparisons to SHERPA+OpenLoops and $W + \geq 1$ jet N_{jetti} NNLO show much better agreement across the entire distribution.

7.2. Enhancement of the collinear fraction with jet p_{T}

The events in the signal region are further divided into two categories based on the transverse momentum of the leading jet: 500 GeV $< p_{\mathrm{T}}^{\text{leading jet}} <$ 600 GeV and $p_{\mathrm{T}}^{\text{leading jet}} >$ 650 GeV. For each of these two categories, the data distribution is unfolded. The 50 GeV gap between the two categories reduces the migration of events from one category to the other during unfolding. The resulting normalised differential $W +$ jets cross-section is shown in Fig. 4. As the leading-jet p_{T} increases, the fraction of events in the lower ΔR (collinear) region increases and the fraction in the higher ΔR (back-to-back $W +$ jets) region decreases. This may be interpreted as an increase in the collinear W emission probability as the jets become more energetic. With higher p_{T} the collinear peak is shifted to smaller ΔR. This is also understood since the mass of the W boson becomes proportionally smaller compared to the energy of the jet. The full measurement results are shown in Fig. 5. The comparison to theory predictions shows results similar to the ones obtained for $p_{\mathrm{T}}^{\text{leading jet}} >$ 500 GeV in Section 7.1.

8. Conclusions

The cross-section for $W \to \mu\nu$ in association with at least one very high transverse momentum jet is measured as a function of the angular distance between the muon from the W boson decay and the closest jet. This measurement utilises data recorded by the ATLAS detector from pp collisions at $\sqrt{s} = 8$ TeV at the LHC, corresponding to 20.3 fb^{-1} of integrated luminosity. These results are relevant to understanding the contribution of real W emissions from high-p_{T} light partons to $W +$ jets processes.

Comparisons to a variety of MC generators and theoretical calculations show varying levels of agreement. ALPGEN+PYTHIA6 overestimates the total cross-section, whereas PYTHIA8, which is modified to explicitly include the process of W boson emission, disagrees with the measurement in the collinear region ($\Delta R <$ 2.4). On the other hand, agreement with the SHERPA+OpenLoops NLO QCD+EW calculation and the $W + \geq 1$ jet N_{jetti} NNLO calculation in Ref. [5] is well within the systematic and statistical uncertainties of the predictions and the measurement.

This measurement has implications for Monte Carlo programs that incorporate real W boson emission, a process which is only just now being probed directly at the energy of the LHC. The rate of this process increases with jet p_{T} and thus also with centre-of-mass energy, and will therefore play a significant role in $W +$ jets measurements at high p_{T}, vector-boson scattering measurements, and even QCD multijet measurements at very large dijet invariant masses where the corrections due to real boson emission are significant.

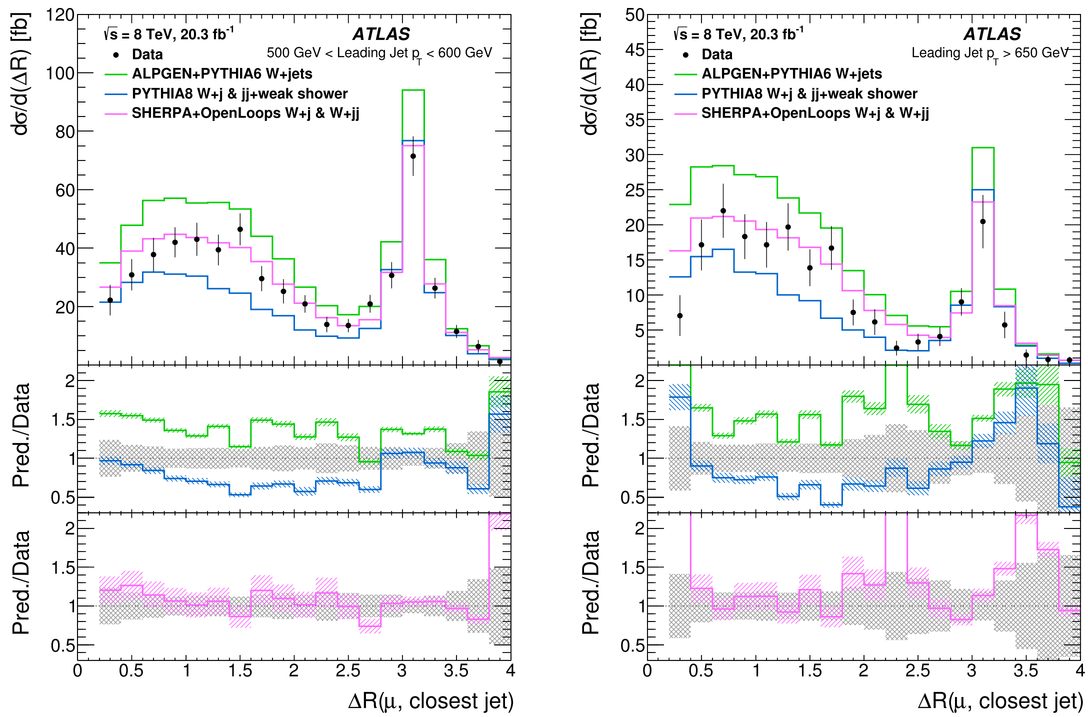
Lastly, the potential is high for this process to mimic the signatures of a highly Lorentz-boosted top quark. The importance of such signatures in the search for new physics at the LHC necessitates a thorough understanding of processes such as the one measured in detail in this paper. As the physics programmes of the LHC experiments extend into new territories in terms of both the centre-of-mass energy and integrated luminosity, these once rare processes will become a ubiquitous consideration.

Acknowledgements

We thank CERN for the very successful operation of the LHC, as well as the support staff from our institutions without whom ATLAS could not be operated efficiently.

We acknowledge the support of ANPCyT, Argentina; YerPhI, Armenia; ARC, Australia; BMWFW and FWF, Austria; ANAS, Azerbaijan; SSTC, Belarus; CNPq and FAPESP, Brazil; NSERC, NRC and CFI, Canada; CERN; CONICYT, Chile; CAS, MOST and NSFC, China; COLCIENCIAS, Colombia; MSMT CR, MPO CR and VSC CR, Czech Republic; DNRF and DNSRC, Denmark; IN2P3-CNRS, CEA-DSM/IRFU, France; GNSF, Georgia; BMBF, HGF, and MPG, Germany; GSRT, Greece; RGC, UGC, Hong Kong SAR, China; ISF, I-CORE and Benoziyo Center, Israel; INFN, Italy; MEXT and JSPS, Japan; CNRST, Morocco; FOM and NWO, Netherlands; RCN, Norway; MNiSW and NCN, Poland; FCT, Portugal; MNE/IFA, Romania; MES of Russia and NRC KI, Russian Federation; JINR; MESTD, Serbia; MSSR, Slovakia; ARRS and MIZŠ, Slovenia; DST/NRF, South Africa; MINECO, Spain; SRC and Knut and Alice Wallenberg Foundation, Sweden; SERI, SNSF and Cantons of Bern and Geneva, Switzerland; MOST, Taiwan; TAEK, Turkey; STFC, United Kingdom; DOE and NSF, United States. In addition, individual groups and members have received support from BCKDF, the Canada Council, CANARIE, CRC, Compute Canada, FQRNT, and the Ontario Innovation Trust, Canada; EPLANET, ERC, FP7, Horizon 2020 and Marie Skłodowska-Curie Actions, European Union; Investissements d'Avenir Labex and Idex, ANR, Région Auvergne and Fondation Partager le Savoir, France; DFG and AvH Foundation, Germany; Herakleitos, Thales and Aristeia programmes co-financed by EU-ESF and the Greek NSRF; BSF, GIF and Minerva, Israel; BRF, Norway; Generalitat de Catalunya, Generalitat Valenciana, Spain; the Royal Society and Leverhulme Trust, United Kingdom.

The crucial computing support from all WLCG partners is acknowledged gratefully, in particular from CERN, the ATLAS Tier-1 facilities at TRIUMF (Canada), NDGF (Denmark, Norway, Sweden), CC-IN2P3 (France), KIT/GridKA (Germany), INFN-CNAF (Italy), NL-T1 (Netherlands), PIC (Spain), ASGC (Taiwan), RAL (UK) and BNL (USA), the Tier-2 facilities worldwide and large non-WLCG resource providers. Major contributors of computing resources are listed in Ref. [61].



(a) (b)

Fig. 5. Unfolded distribution from background-subtracted data of the angular separation between the muon and the closest jet in the signal region along with several predictions from theory calculations for events with (a) 500 GeV $< p_T^{\text{leading jet}} <$ 600 GeV and (b) $p_T^{\text{leading jet}} >$ 650 GeV. The lower panels show the ratio of the theory predictions to the unfolded data. The error bars in the upper panel and the grey shaded error bands in the lower ratio panels are the sum of the statistical and systematic uncertainties in the measurement. The shaded error band on the ALPGEN+PYTHIA6 calculation is statistical uncertainty, the band on the PYTHIA8 calculation is statistical and PDF uncertainties and the band on the SHERPA+OpenLoops is scale uncertainty.

References

[1] U. Baur, Weak boson emission in hadron collider processes, Phys. Rev. D 75 (2007) 013005, arXiv:hep-ph/0611241.

[2] J.R. Christiansen, T. Sjöstrand, Weak gauge boson radiation in parton showers, J. High Energy Phys. 04 (2014) 115, arXiv:1401.5238 [hep-ph].

[3] F. Krauss, P. Petrov, M. Schönherr, M. Spannowsky, Measuring collinear W emissions inside jets, Phys. Rev. D 89 (2014) 114006, arXiv:1403.4788 [hep-ph].

[4] R. Boughezal, C. Focke, X. Liu, Jet vetoes versus giant K-factors in the exclusive $Z+1$-jet cross section, Phys. Rev. D 92 (2015) 094002, arXiv:1501.01059 [hep-ph].

[5] R. Boughezal, X. Liu, F. Petriello, W-boson plus jet differential distributions at NNLO in QCD, arXiv:1602.06965 [hep-ph].

[6] J.R. Christiansen, S. Prestel, Merging weak and QCD showers with matrix elements, Eur. Phys. J. C 76 (2016) 39, arXiv:1510.01517 [hep-ph].

[7] ATLAS Collaboration, Measurements of the W production cross sections in association with jets with the ATLAS detector, Eur. Phys. J. C 75 (2015) 82, arXiv:1409.8639 [hep-ex].

[8] CMS Collaboration, Differential cross section measurements for the production of a W boson in association with jets in proton–proton collisions at $\sqrt{s}=7$ TeV, Phys. Lett. B 741 (2015) 12, arXiv:1406.7533 [hep-ex].

[9] K. Rehermann, B. Tweedie, Efficient identification of boosted semileptonic top quarks at the LHC, J. High Energy Phys. 03 (2011) 059, arXiv:1007.2221 [hep-ph].

[10] ATLAS Collaboration, The ATLAS experiment at the CERN large hadron collider, J. Instrum. 3 (2008) S08003.

[11] ATLAS Collaboration, Performance of the ATLAS detector using first collision data, J. High Energy Phys. 09 (2010) 056, arXiv:1005.5254 [hep-ex].

[12] ATLAS Collaboration, Charged-particle multiplicities in pp interactions measured with the ATLAS detector at the LHC, New J. Phys. 13 (2011) 053033, arXiv:1012.5104 [hep-ex].

[13] ATLAS Collaboration, Performance of the ATLAS Trigger System in 2010, Eur. Phys. J. C 72 (2012) 1849, arXiv:1110.1530 [hep-ex].

[14] ATLAS Collaboration, Monitoring and data quality assessment of the ATLAS liquid argon calorimeter, J. Instrum. 9 (2014) P07024, arXiv:1405.3768 [hep-ex].

[15] ATLAS Collaboration, Luminosity determination in pp collisions at $\sqrt{s}=8$ TeV using the ATLAS detector at the LHC, arXiv:1608.03953 [hep-ex].

[16] GEANT4 Collaboration, S. Agostinelli, et al., GEANT4: a simulation toolkit, Nucl. Instrum. Methods A 506 (2003) 250.

[17] ATLAS Collaboration, The ATLAS simulation infrastructure, Eur. Phys. J. C 70 (2010) 823, arXiv:1005.4568 [physics.ins-det].

[18] T. Sjöstrand, S. Mrenna, P.Z. Skands, A brief introduction to PYTHIA 8.1, Comput. Phys. Commun. 178 (2008) 852, arXiv:0710.3820 [hep-ph].

[19] ATLAS Collaboration, Summary of ATLAS Pythia 8 tunes, ATL-PHYS-PUB-2012-003, http://cds.cern.ch/record/1474107, 2012.

[20] A.D. Martin, W.J. Stirling, R.S. Thorne, G. Watt, Parton distributions for the LHC, Eur. Phys. J. C 63 (2009) 189, arXiv:0901.0002 [hep-ph].

[21] M.L. Mangano, F. Piccinini, A.D. Polosa, M. Moretti, R. Pittau, ALPGEN, a generator for hard multiparton processes in hadronic collisions, J. High Energy Phys. 07 (2003) 001, arXiv:hep-ph/0206293.

[22] M.L. Mangano, M. Moretti, F. Piccinini, M. Treccani, Matching matrix elements and shower evolution for top-quark production in hadronic collisions, J. High Energy Phys. 01 (2007) 013, arXiv:hep-ph/0611129.

[23] T. Sjöstrand, S. Mrenna, P.Z. Skands, PYTHIA 6.4 physics and manual, J. High Energy Phys. 05 (2006) 026, arXiv:hep-ph/0603175.

[24] J. Pumplin, et al., New generation of parton distributions with uncertainties from global QCD analysis, J. High Energy Phys. 07 (2002) 012, arXiv:hep-ph/0201195.

[25] K. Melnikov, F. Petriello, Electroweak gauge boson production at hadron colliders through $\mathcal{O}(\alpha_s^2)$, Phys. Rev. D 74 (2006) 114017, arXiv:hep-ph/0609070.

[26] H.-L. Lai, et al., New parton distributions for collider physics, Phys. Rev. D 82 (2010) 074024, arXiv:1007.2241 [hep-ph].

[27] P. Nason, A new method for combining NLO QCD with shower Monte Carlo algorithms, J. High Energy Phys. 11 (2004) 040, arXiv:hep-ph/0409146.

[28] S. Frixione, P. Nason, C. Oleari, Matching NLO QCD computations with Parton Shower simulations: the POWHEG method, J. High Energy Phys. 11 (2007) 070, arXiv:0709.2092 [hep-ph].

[29] S. Alioli, P. Nason, C. Oleari, E. Re, A general framework for implementing NLO calculations in shower Monte Carlo programs: the POWHEG BOX, J. High Energy Phys. 06 (2010) 043, arXiv:1002.2581 [hep-ph].

[30] S. Frixione, P. Nason, G. Ridolfi, A positive-weight next-to-leading-order Monte Carlo for heavy flavour hadroproduction, J. High Energy Phys. 09 (2007) 126, arXiv:0707.3088 [hep-ph].
[31] P.Z. Skands, Tuning Monte Carlo generators: the Perugia tunes, Phys. Rev. D 82 (2010) 074018, arXiv:1005.3457 [hep-ph].
[32] S. Frixione, B.R. Webber, Matching NLO QCD computations and parton shower simulations, J. High Energy Phys. 06 (2002) 029, arXiv:hep-ph/0204244.
[33] T. Gleisberg, et al., Event generation with SHERPA 1.1, J. High Energy Phys. 02 (2009) 007, arXiv:0811.4622 [hep-ph].
[34] ATLAS Collaboration, Characterisation and mitigation of beam-induced backgrounds observed in the ATLAS detector during the 2011 proton–proton run, J. Instrum. 8 (2013) P07004, arXiv:1303.0223 [hep-ex].
[35] M. Cacciari, G.P. Salam, Dispelling the N^3 myth for the k_t jet-finder, Phys. Lett. B 641 (2006) 57, arXiv:hep-ph/0512210.
[36] M. Cacciari, G.P. Salam, G. Soyez, The anti-k_t jet clustering algorithm, J. High Energy Phys. 04 (2008) 063, arXiv:0802.1189 [hep-ph].
[37] ATLAS Collaboration, Performance of the ATLAS muon trigger in *pp* collisions at $\sqrt{s} = 8$ TeV, Eur. Phys. J. C 75 (2015) 120, arXiv:1408.3179 [hep-ex].
[38] ATLAS Collaboration, Measurement of the muon reconstruction performance of the ATLAS detector using 2011 and 2012 LHC proton–proton collision data, Eur. Phys. J. C 74 (2014) 3130, arXiv:1407.3935 [hep-ex].
[39] ATLAS Collaboration, Topological cell clustering in the ATLAS calorimeters and its performance in LHC Run 1, arXiv:1603.02934 [hep-ex].
[40] ATLAS Collaboration, Performance of *b*-jet identification in the ATLAS experiment, J. Instrum. 11 (2016) P04008, arXiv:1512.01094 [hep-ex].
[41] ATLAS Collaboration, Electron reconstruction and identification efficiency measurements with the ATLAS detector using the 2011 LHC proton–proton collision data, Eur. Phys. J. C 74 (2014) 2941, arXiv:1404.2240 [hep-ex].
[42] ATLAS Collaboration, Electron and photon energy calibration with the ATLAS detector using LHC Run 1 data, Eur. Phys. J. C 74 (2014) 3071, arXiv:1407.5063 [hep-ex].
[43] G. D'Agostini, Improved iterative Bayesian unfolding, arXiv:1010.0632 [physics.data-an].
[44] T. Adye, R. Claridge, K. Tackmann, F. Wilson, RooUnfold: ROOT unfolding framework, http://hepunx.rl.ac.uk/~adye/software/unfold/RooUnfold.html.
[45] C. Buttar, et al., Standard model handles and candles working group: tools and jets summary report, arXiv:0803.0678 [hep-ph].
[46] ATLAS Collaboration, Jet energy measurement and its systematic uncertainty in proton–proton collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector, Eur. Phys. J. C 75 (2015) 17, arXiv:1406.0076 [hep-ex].
[47] ATLAS Collaboration, Calibration of the performance of *b*-tagging for *c* and light-flavour jets in the 2012 ATLAS data, ATLAS-CONF-2014-046, https://cds.cern.ch/record/1741020, 2014.
[48] ATLAS Collaboration, Calibration of *b*-tagging using dileptonic top pair events in a combinatorial likelihood approach with the ATLAS experiment, ATLAS-CONF-2014-004, https://cds.cern.ch/record/1664335, 2014.
[49] ATLAS Collaboration, Jet energy resolution in proton–proton collisions at $\sqrt{s} = 7$ TeV recorded in 2010 with the ATLAS detector, Eur. Phys. J. C 73 (2013) 2306, arXiv:1210.6210 [hep-ex].
[50] S. Kallweit, J.M. Lindert, P. Maierhöfer, S. Pozzorini, M. Schönherr, NLO QCD+EW predictions for V + jets including off-shell vector-boson decays and multijet merging, J. High Energy Phys. 04 (2016) 021, arXiv:1511.08692 [hep-ph].
[51] S. Kallweit, J.M. Lindert, P. Maierhöfer, S. Pozzorini, M. Schönherr, NLO electroweak automation and precise predictions for $W +$ multijet production at the LHC, J. High Energy Phys. 04 (2015) 012, arXiv:1412.5157 [hep-ph].
[52] F. Krauss, R. Kuhn, G. Soff, AMEGIC++ 1.0: a matrix element generator in C++, J. High Energy Phys. 02 (2002) 044, arXiv:hep-ph/0109036.
[53] T. Gleisberg, F. Krauss, Automating dipole subtraction for QCD NLO calculations, Eur. Phys. J. C 53 (2008) 501, arXiv:0709.2881 [hep-ph].
[54] F. Cascioli, P. Maierhöfer, S. Pozzorini, Scattering amplitudes with open loops, Phys. Rev. Lett. 108 (2012) 111601, arXiv:1111.5206 [hep-ph].
[55] A. Denner, S. Dittmaier, L. Hofer, COLLIER – a fortran-library for one-loop integrals, PoS LL2014 (2014) 071, arXiv:1407.0087 [hep-ph].
[56] NNPDF Collaboration, R.D. Ball, et al., Parton distributions with QED corrections, Nucl. Phys. B 877 (2013) 290, arXiv:1308.0598 [hep-ph].
[57] R. Boughezal, C. Focke, X. Liu, F. Petriello, W-boson production in association with a jet at next-to-next-to-leading order in perturbative QCD, Phys. Rev. Lett. 115 (2015) 062002, arXiv:1504.02131 [hep-ph].
[58] R. Boughezal, X. Liu, F. Petriello, A comparison of NNLO QCD predictions with 7 TeV ATLAS and CMS data for $V +$ jet processes, Phys. Lett. B 760 (2016) 6, arXiv:1602.05612 [hep-ph].
[59] J.R. Gaunt, M. Stahlhofen, F.J. Tackmann, J.R. Walsh, N-jettiness subtractions for NNLO QCD calculations, J. High Energy Phys. 09 (2015) 058, arXiv:1505.04794 [hep-ph].
[60] S. Dulat, et al., New parton distribution functions from a global analysis of quantum chromodynamics, Phys. Rev. D 93 (2016) 033006, arXiv:1506.07443 [hep-ph].
[61] ATLAS Collaboration, ATLAS computing acknowledgements 2016–2017, ATL–GEN-PUB-2016–ATL-GEN-PUB-002, http://cds.cern.ch/record/2202407.

The ATLAS Collaboration

M. Aaboud [136d], G. Aad [87], B. Abbott [114], J. Abdallah [8], O. Abdinov [12], B. Abeloos [118], R. Aben [108], O.S. AbouZeid [138], N.L. Abraham [152], H. Abramowicz [156], H. Abreu [155], R. Abreu [117], Y. Abulaiti [149a,149b], B.S. Acharya [168a,168b,a], S. Adachi [158], L. Adamczyk [40a], D.L. Adams [27], J. Adelman [109], S. Adomeit [101], T. Adye [132], A.A. Affolder [76], T. Agatonovic-Jovin [14], J.A. Aguilar-Saavedra [127a,127f], S.P. Ahlen [24], F. Ahmadov [67,b], G. Aielli [134a,134b], H. Akerstedt [149a,149b], T.P.A. Åkesson [83], A.V. Akimov [97], G.L. Alberghi [22a,22b], J. Albert [173], S. Albrand [57], M.J. Alconada Verzini [73], M. Aleksa [32], I.N. Aleksandrov [67], C. Alexa [28b], G. Alexander [156], T. Alexopoulos [10], M. Alhroob [114], B. Ali [129], M. Aliev [75a,75b], G. Alimonti [93a], J. Alison [33], S.P. Alkire [37], B.M.M. Allbrooke [152], B.W. Allen [117], P.P. Allport [19], A. Aloisio [105a,105b], A. Alonso [38], F. Alonso [73], C. Alpigiani [139], A.A. Alshehri [55], M. Alstaty [87], B. Alvarez Gonzalez [32], D. Álvarez Piqueras [171], M.G. Alviggi [105a,105b], B.T. Amadio [16], K. Amako [68], Y. Amaral Coutinho [26a], C. Amelung [25], D. Amidei [91], S.P. Amor Dos Santos [127a,127c], A. Amorim [127a,127b], S. Amoroso [32], G. Amundsen [25], C. Anastopoulos [142], L.S. Ancu [51], N. Andari [19], T. Andeen [11], C.F. Anders [60b], G. Anders [32], J.K. Anders [76], K.J. Anderson [33], A. Andreazza [93a,93b], V. Andrei [60a], S. Angelidakis [9], I. Angelozzi [108], A. Angerami [37], F. Anghinolfi [32], A.V. Anisenkov [110,c], N. Anjos [13], A. Annovi [125a,125b], C. Antel [60a], M. Antonelli [49], A. Antonov [99,*], F. Anulli [133a], M. Aoki [68], L. Aperio Bella [19], G. Arabidze [92], Y. Arai [68], J.P. Araque [127a], A.T.H. Arce [47], F.A. Arduh [73], J-F. Arguin [96], S. Argyropoulos [65], M. Arik [20a], A.J. Armbruster [146], L.J. Armitage [78], O. Arnaez [32], H. Arnold [50], M. Arratia [30], O. Arslan [23], A. Artamonov [98], G. Artoni [121], S. Artz [85], S. Asai [158], N. Asbah [44], A. Ashkenazi [156], B. Åsman [149a,149b], L. Asquith [152], K. Assamagan [27], R. Astalos [147a], M. Atkinson [170], N.B. Atlay [144], K. Augsten [129], G. Avolio [32], B. Axen [16], M.K. Ayoub [118], G. Azuelos [96,d], M.A. Baak [32], A.E. Baas [60a], M.J. Baca [19], H. Bachacou [137], K. Bachas [75a,75b], M. Backes [121], M. Backhaus [32], P. Bagiacchi [133a,133b], P. Bagnaia [133a,133b], Y. Bai [35a], J.T. Baines [132], O.K. Baker [180], E.M. Baldin [110,c], P. Balek [176], T. Balestri [151], F. Balli [137], W.K. Balunas [123],

E. Banas [41], Sw. Banerjee [177,e], A.A.E. Bannoura [179], L. Barak [32], E.L. Barberio [90], D. Barberis [52a,52b], M. Barbero [87], T. Barillari [102], M-S Barisits [32], T. Barklow [146], N. Barlow [30], S.L. Barnes [86], B.M. Barnett [132], R.M. Barnett [16], Z. Barnovska-Blenessy [59], A. Baroncelli [135a], G. Barone [25], A.J. Barr [121], L. Barranco Navarro [171], F. Barreiro [84], J. Barreiro Guimarães da Costa [35a], R. Bartoldus [146], A.E. Barton [74], P. Bartos [147a], A. Basalaev [124], A. Bassalat [118,f], R.L. Bates [55], S.J. Batista [162], J.R. Batley [30], M. Battaglia [138], M. Bauce [133a,133b], F. Bauer [137], H.S. Bawa [146,g], J.B. Beacham [112], M.D. Beattie [74], T. Beau [82], P.H. Beauchemin [166], P. Bechtle [23], H.P. Beck [18,h], K. Becker [121], M. Becker [85], M. Beckingham [174], C. Becot [111], A.J. Beddall [20e], A. Beddall [20b], V.A. Bednyakov [67], M. Bedognetti [108], C.P. Bee [151], L.J. Beemster [108], T.A. Beermann [32], M. Begel [27], J.K. Behr [44], C. Belanger-Champagne [89], A.S. Bell [80], G. Bella [156], L. Bellagamba [22a], A. Bellerive [31], M. Bellomo [88], K. Belotskiy [99], O. Beltramello [32], N.L. Belyaev [99], O. Benary [156,*], D. Benchekroun [136a], M. Bender [101], K. Bendtz [149a,149b], N. Benekos [10], Y. Benhammou [156], E. Benhar Noccioli [180], J. Benitez [65], D.P. Benjamin [47], J.R. Bensinger [25], S. Bentvelsen [108], L. Beresford [121], M. Beretta [49], D. Berge [108], E. Bergeaas Kuutmann [169], N. Berger [5], J. Beringer [16], S. Berlendis [57], N.R. Bernard [88], C. Bernius [111], F.U. Bernlochner [23], T. Berry [79], P. Berta [130], C. Bertella [85], G. Bertoli [149a,149b], F. Bertolucci [125a,125b], I.A. Bertram [74], C. Bertsche [44], D. Bertsche [114], G.J. Besjes [38], O. Bessidskaia Bylund [149a,149b], M. Bessner [44], N. Besson [137], C. Betancourt [50], A. Bethani [57], S. Bethke [102], A.J. Bevan [78], R.M. Bianchi [126], L. Bianchini [25], M. Bianco [32], O. Biebel [101], D. Biedermann [17], R. Bielski [86], N.V. Biesuz [125a,125b], M. Biglietti [135a], J. Bilbao De Mendizabal [51], T.R.V. Billoud [96], H. Bilokon [49], M. Bindi [56], S. Binet [118], A. Bingul [20b], C. Bini [133a,133b], S. Biondi [22a,22b], T. Bisanz [56], D.M. Bjergaard [47], C.W. Black [153], J.E. Black [146], K.M. Black [24], D. Blackburn [139], R.E. Blair [6], J.-B. Blanchard [137], T. Blazek [147a], I. Bloch [44], C. Blocker [25], A. Blue [55], W. Blum [85,*], U. Blumenschein [56], S. Blunier [34a], G.J. Bobbink [108], V.S. Bobrovnikov [110,c], S.S. Bocchetta [83], A. Bocci [47], C. Bock [101], M. Boehler [50], D. Boerner [179], J.A. Bogaerts [32], D. Bogavac [14], A.G. Bogdanchikov [110], C. Bohm [149a], V. Boisvert [79], P. Bokan [14], T. Bold [40a], A.S. Boldyrev [168a,168c], M. Bomben [82], M. Bona [78], M. Boonekamp [137], A. Borisov [131], G. Borissov [74], J. Bortfeldt [32], D. Bortoletto [121], V. Bortolotto [62a,62b,62c], K. Bos [108], D. Boscherini [22a], M. Bosman [13], J.D. Bossio Sola [29], J. Boudreau [126], J. Bouffard [2], E.V. Bouhova-Thacker [74], D. Boumediene [36], C. Bourdarios [118], S.K. Boutle [55], A. Boveia [32], J. Boyd [32], I.R. Boyko [67], J. Bracinik [19], A. Brandt [8], G. Brandt [56], O. Brandt [60a], U. Bratzler [159], B. Brau [88], J.E. Brau [117], W.D. Breaden Madden [55], K. Brendlinger [123], A.J. Brennan [90], L. Brenner [108], R. Brenner [169], S. Bressler [176], T.M. Bristow [48], D. Britton [55], D. Britzger [44], F.M. Brochu [30], I. Brock [23], R. Brock [92], G. Brooijmans [37], T. Brooks [79], W.K. Brooks [34b], J. Brosamer [16], E. Brost [109], J.H Broughton [19], P.A. Bruckman de Renstrom [41], D. Bruncko [147b], R. Bruneliere [50], A. Bruni [22a], G. Bruni [22a], L.S. Bruni [108], BH Brunt [30], M. Bruschi [22a], N. Bruscino [23], P. Bryant [33], L. Bryngemark [83], T. Buanes [15], Q. Buat [145], P. Buchholz [144], A.G. Buckley [55], I.A. Budagov [67], F. Buehrer [50], M.K. Bugge [120], O. Bulekov [99], D. Bullock [8], H. Burckhart [32], S. Burdin [76], C.D. Burgard [50], B. Burghgrave [109], K. Burka [41], S. Burke [132], I. Burmeister [45], J.T.P. Burr [121], E. Busato [36], D. Büscher [50], V. Büscher [85], P. Bussey [55], J.M. Butler [24], C.M. Buttar [55], J.M. Butterworth [80], P. Butti [108], W. Buttinger [27], A. Buzatu [55], A.R. Buzykaev [110,c], S. Cabrera Urbán [171], D. Caforio [129], V.M. Cairo [39a,39b], O. Cakir [4a], N. Calace [51], P. Calafiura [16], A. Calandri [87], G. Calderini [82], P. Calfayan [63], G. Callea [39a,39b], L.P. Caloba [26a], S. Calvente Lopez [84], D. Calvet [36], S. Calvet [36], T.P. Calvet [87], R. Camacho Toro [33], S. Camarda [32], P. Camarri [134a,134b], D. Cameron [120], R. Caminal Armadans [170], C. Camincher [57], S. Campana [32], M. Campanelli [80], A. Camplani [93a,93b], A. Campoverde [144], V. Canale [105a,105b], A. Canepa [164a], M. Cano Bret [141], J. Cantero [115], T. Cao [42], M.D.M. Capeans Garrido [32], I. Caprini [28b], M. Caprini [28b], M. Capua [39a,39b], R.M. Carbone [37], R. Cardarelli [134a], F. Cardillo [50], I. Carli [130], T. Carli [32], G. Carlino [105a], L. Carminati [93a,93b], R.M.D. Carney [149a,149b], S. Caron [107], E. Carquin [34b], G.D. Carrillo-Montoya [32], J.R. Carter [30], J. Carvalho [127a,127c], D. Casadei [19], M.P. Casado [13,i], M. Casolino [13], D.W. Casper [167], E. Castaneda-Miranda [148a], R. Castelijn [108], A. Castelli [108], V. Castillo Gimenez [171], N.F. Castro [127a,j], A. Catinaccio [32], J.R. Catmore [120], A. Cattai [32], J. Caudron [23], V. Cavaliere [170], E. Cavallaro [13], D. Cavalli [93a], M. Cavalli-Sforza [13], V. Cavasinni [125a,125b], F. Ceradini [135a,135b], L. Cerda Alberich [171], A.S. Cerqueira [26b], A. Cerri [152], L. Cerrito [134a,134b], F. Cerutti [16], M. Cerv [32], A. Cervelli [18], S.A. Cetin [20d], A. Chafaq [136a], D. Chakraborty [109], S.K. Chan [58], Y.L. Chan [62a], P. Chang [170], J.D. Chapman [30], D.G. Charlton [19], A. Chatterjee [51], C.C. Chau [162], C.A. Chavez Barajas [152], S. Che [112], S. Cheatham [168a,168c], A. Chegwidden [92], S. Chekanov [6], S.V. Chekulaev [164a], G.A. Chelkov [67,k], M.A. Chelstowska [91], C. Chen [66], H. Chen [27], K. Chen [151], S. Chen [35b], S. Chen [158], X. Chen [35c], Y. Chen [69], H.C. Cheng [91], H.J Cheng [35a], Y. Cheng [33], A. Cheplakov [67], E. Cheremushkina [131], R. Cherkaoui El Moursli [136e], V. Chernyatin [27,∗], E. Cheu [7], L. Chevalier [137], V. Chiarella [49], G. Chiarelli [125a,125b], G. Chiodini [75a], A.S. Chisholm [32], A. Chitan [28b], M.V. Chizhov [67], K. Choi [63], A.R. Chomont [36], S. Chouridou [9], B.K.B. Chow [101], V. Christodoulou [80], D. Chromek-Burckhart [32], J. Chudoba [128], A.J. Chuinard [89], J.J. Chwastowski [41], L. Chytka [116], G. Ciapetti [133a,133b], A.K. Ciftci [4a], D. Cinca [45], V. Cindro [77], I.A. Cioara [23], C. Ciocca [22a,22b], A. Ciocio [16], F. Cirotto [105a,105b], Z.H. Citron [176], M. Citterio [93a], M. Ciubancan [28b], A. Clark [51], B.L. Clark [58], M.R. Clark [37], P.J. Clark [48], R.N. Clarke [16], C. Clement [149a,149b], Y. Coadou [87], M. Cobal [168a,168c], A. Coccaro [51], J. Cochran [66], L. Colasurdo [107], B. Cole [37], A.P. Colijn [108], J. Collot [57], T. Colombo [167], G. Compostella [102], P. Conde Muiño [127a,127b], E. Coniavitis [50], S.H. Connell [148b], I.A. Connelly [79], V. Consorti [50], S. Constantinescu [28b], G. Conti [32], F. Conventi [105a,l], M. Cooke [16], B.D. Cooper [80], A.M. Cooper-Sarkar [121], K.J.R. Cormier [162], T. Cornelissen [179], M. Corradi [133a,133b], F. Corriveau [89,m], A. Cortes-Gonzalez [32], G. Cortiana [102], G. Costa [93a], M.J. Costa [171], D. Costanzo [142], G. Cottin [30], G. Cowan [79], B.E. Cox [86], K. Cranmer [111], S.J. Crawley [55], G. Cree [31], S. Crépé-Renaudin [57], F. Crescioli [82], W.A. Cribbs [149a,149b], M. Crispin Ortuzar [121], M. Cristinziani [23], V. Croft [107], G. Crosetti [39a,39b], A. Cueto [84], T. Cuhadar Donszelmann [142], J. Cummings [180], M. Curatolo [49], J. Cúth [85], H. Czirr [144], P. Czodrowski [3], G. D'amen [22a,22b], S. D'Auria [55], M. D'Onofrio [76], M.J. Da Cunha Sargedas De Sousa [127a,127b], C. Da Via [86], W. Dabrowski [40a], T. Dado [147a], T. Dai [91], O. Dale [15], F. Dallaire [96], C. Dallapiccola [88], M. Dam [38], J.R. Dandoy [33], N.P. Dang [50], A.C. Daniells [19], N.S. Dann [86], M. Danninger [172], M. Dano Hoffmann [137], V. Dao [50], G. Darbo [52a], S. Darmora [8], J. Dassoulas [3], A. Dattagupta [117], W. Davey [23], C. David [173], T. Davidek [130], M. Davies [156], P. Davison [80], E. Dawe [90], I. Dawson [142], K. De [8], R. de Asmundis [105a], A. De Benedetti [114], S. De Castro [22a,22b], S. De Cecco [82], N. De Groot [107], P. de Jong [108], H. De la Torre [92], F. De Lorenzi [66], A. De Maria [56], D. De Pedis [133a], A. De Salvo [133a], U. De Sanctis [152], A. De Santo [152], J.B. De Vivie De Regie [118], W.J. Dearnaley [74], R. Debbe [27], C. Debenedetti [138], D.V. Dedovich [67], N. Dehghanian [3], I. Deigaard [108], M. Del Gaudio [39a,39b], J. Del Peso [84], T. Del Prete [125a,125b], D. Delgove [118], F. Deliot [137], C.M. Delitzsch [51], A. Dell'Acqua [32], L. Dell'Asta [24], M. Dell'Orso [125a,125b], M. Della Pietra [105a,l], D. della Volpe [51], M. Delmastro [5], P.A. Delsart [57], D.A. DeMarco [162], S. Demers [180], M. Demichev [67], A. Demilly [82], S.P. Denisov [131], D. Denysiuk [137], D. Derendarz [41], J.E. Derkaoui [136d], F. Derue [82], P. Dervan [76], K. Desch [23], C. Deterre [44], K. Dette [45], P.O. Deviveiros [32], A. Dewhurst [132], S. Dhaliwal [25], A. Di Ciaccio [134a,134b], L. Di Ciaccio [5], W.K. Di Clemente [123], C. Di Donato [105a,105b], A. Di Girolamo [32], B. Di Girolamo [32], B. Di Micco [135a,135b], R. Di Nardo [32], A. Di Simone [50], R. Di Sipio [162], D. Di Valentino [31], C. Diaconu [87], M. Diamond [162], F.A. Dias [48], M.A. Diaz [34a], E.B. Diehl [91], J. Dietrich [17], S. Díez Cornell [44], A. Dimitrievska [14], J. Dingfelder [23], P. Dita [28b], S. Dita [28b], F. Dittus [32], F. Djama [87], T. Djobava [53b], J.I. Djuvsland [60a], M.A.B. do Vale [26c], D. Dobos [32], M. Dobre [28b], C. Doglioni [83], J. Dolejsi [130], Z. Dolezal [130], M. Donadelli [26d], S. Donati [125a,125b], P. Dondero [122a,122b], J. Donini [36], J. Dopke [132], A. Doria [105a], M.T. Dova [73], A.T. Doyle [55], E. Drechsler [56], M. Dris [10], Y. Du [140], J. Duarte-Campderros [156], E. Duchovni [176], G. Duckeck [101], O.A. Ducu [96,n], D. Duda [108], A. Dudarev [32], A. Chr. Dudder [85], E.M. Duffield [16], L. Duflot [118], M. Dührssen [32], M. Dumancic [176], M. Dunford [60a], H. Duran Yildiz [4a], M. Düren [54], A. Durglishvili [53b], D. Duschinger [46], B. Dutta [44], M. Dyndal [44], C. Eckardt [44], K.M. Ecker [102], R.C. Edgar [91], N.C. Edwards [48], T. Eifert [32], G. Eigen [15], K. Einsweiler [16], T. Ekelof [169], M. El Kacimi [136c], V. Ellajosyula [87], M. Ellert [169], S. Elles [5], F. Ellinghaus [179], A.A. Elliot [173], N. Ellis [32], J. Elmsheuser [27], M. Elsing [32], D. Emeliyanov [132], Y. Enari [158], O.C. Endner [85], J.S. Ennis [174], J. Erdmann [45], A. Ereditato [18], G. Ernis [179], J. Ernst [2], M. Ernst [27], S. Errede [170], E. Ertel [85], M. Escalier [118], H. Esch [45], C. Escobar [126], B. Esposito [49], A.I. Etienvre [137], E. Etzion [156], H. Evans [63], A. Ezhilov [124], M. Ezzi [136e], F. Fabbri [22a,22b], L. Fabbri [22a,22b], G. Facini [33], R.M. Fakhrutdinov [131], S. Falciano [133a], R.J. Falla [80], J. Faltova [32], Y. Fang [35a], M. Fanti [93a,93b], A. Farbin [8], A. Farilla [135a], C. Farina [126], E.M. Farina [122a,122b], T. Farooque [13], S. Farrell [16], S.M. Farrington [174], P. Farthouat [32], F. Fassi [136e], P. Fassnacht [32], D. Fassouliotis [9], M. Faucci Giannelli [79], A. Favareto [52a,52b], W.J. Fawcett [121], L. Fayard [118], O.L. Fedin [124,o], W. Fedorko [172], S. Feigl [120], L. Feligioni [87], C. Feng [140], E.J. Feng [32], H. Feng [91], A.B. Fenyuk [131], L. Feremenga [8], P. Fernandez Martinez [171], S. Fernandez Perez [13], J. Ferrando [44], A. Ferrari [169], P. Ferrari [108], R. Ferrari [122a], D.E. Ferreira de Lima [60b], A. Ferrer [171], D. Ferrere [51], C. Ferretti [91], A. Ferretto Parodi [52a,52b], F. Fiedler [85], A. Filipčič [77], M. Filipuzzi [44],

F. Filthaut [107], M. Fincke-Keeler [173], K.D. Finelli [153], M.C.N. Fiolhais [127a,127c], L. Fiorini [171], A. Firan [42], A. Fischer [2], C. Fischer [13], J. Fischer [179], W.C. Fisher [92], N. Flaschel [44], I. Fleck [144], P. Fleischmann [91], G.T. Fletcher [142], R.R.M. Fletcher [123], T. Flick [179], L.R. Flores Castillo [62a], M.J. Flowerdew [102], G.T. Forcolin [86], A. Formica [137], A. Forti [86], A.G. Foster [19], D. Fournier [118], H. Fox [74], S. Fracchia [13], P. Francavilla [82], M. Franchini [22a,22b], D. Francis [32], L. Franconi [120], M. Franklin [58], M. Frate [167], M. Fraternali [122a,122b], D. Freeborn [80], S.M. Fressard-Batraneanu [32], F. Friedrich [46], D. Froidevaux [32], J.A. Frost [121], C. Fukunaga [159], E. Fullana Torregrosa [85], T. Fusayasu [103], J. Fuster [171], C. Gabaldon [57], O. Gabizon [155], A. Gabrielli [22a,22b], A. Gabrielli [16], G.P. Gach [40a], S. Gadatsch [32], S. Gadomski [79], G. Gagliardi [52a,52b], L.G. Gagnon [96], P. Gagnon [63], C. Galea [107], B. Galhardo [127a,127c], E.J. Gallas [121], B.J. Gallop [132], P. Gallus [129], G. Galster [38], K.K. Gan [112], S. Ganguly [36], J. Gao [59], Y. Gao [48], Y.S. Gao [146,g], F.M. Garay Walls [48], C. García [171], J.E. García Navarro [171], M. Garcia-Sciveres [16], R.W. Gardner [33], N. Garelli [146], V. Garonne [120], A. Gascon Bravo [44], K. Gasnikova [44], C. Gatti [49], A. Gaudiello [52a,52b], G. Gaudio [122a], L. Gauthier [96], I.L. Gavrilenko [97], C. Gay [172], G. Gaycken [23], E.N. Gazis [10], Z. Gecse [172], C.N.P. Gee [132], Ch. Geich-Gimbel [23], M. Geisen [85], M.P. Geisler [60a], K. Gellerstedt [149a,149b], C. Gemme [52a], M.H. Genest [57], C. Geng [59,p], S. Gentile [133a,133b], C. Gentsos [157], S. George [79], D. Gerbaudo [13], A. Gershon [156], S. Ghasemi [144], M. Ghneimat [23], B. Giacobbe [22a], S. Giagu [133a,133b], P. Giannetti [125a,125b], B. Gibbard [27], S.M. Gibson [79], M. Gignac [172], M. Gilchriese [16], T.P.S. Gillam [30], D. Gillberg [31], G. Gilles [179], D.M. Gingrich [3,d], N. Giokaris [9], M.P. Giordani [168a,168c], F.M. Giorgi [22a], F.M. Giorgi [17], P.F. Giraud [137], P. Giromini [58], D. Giugni [93a], F. Giuli [121], C. Giuliani [102], M. Giulini [60b], B.K. Gjelsten [120], S. Gkaitatzis [157], I. Gkialas [157], E.L. Gkougkousis [118], L.K. Gladilin [100], C. Glasman [84], J. Glatzer [50], P.C.F. Glaysher [48], A. Glazov [44], M. Goblirsch-Kolb [25], J. Godlewski [41], S. Goldfarb [90], T. Golling [51], D. Golubkov [131], A. Gomes [127a,127b,127d], R. Gonçalo [127a], J. Goncalves Pinto Firmino Da Costa [137], G. Gonella [50], L. Gonella [19], A. Gongadze [67], S. González de la Hoz [171], S. Gonzalez-Sevilla [51], L. Goossens [32], P.A. Gorbounov [98], H.A. Gordon [27], I. Gorelov [106], B. Gorini [32], E. Gorini [75a,75b], A. Gorišek [77], E. Gornicki [41], A.T. Goshaw [47], C. Gössling [45], M.I. Gostkin [67], C.R. Goudet [118], D. Goujdami [136c], A.G. Goussiou [139], N. Govender [148b,q], E. Gozani [155], L. Graber [56], I. Grabowska-Bold [40a], P.O.J. Gradin [57], P. Grafström [22a,22b], J. Gramling [51], E. Gramstad [120], S. Grancagnolo [17], V. Gratchev [124], P.M. Gravila [28e], H.M. Gray [32], E. Graziani [135a], Z.D. Greenwood [81,r], C. Grefe [23], K. Gregersen [80], I.M. Gregor [44], P. Grenier [146], K. Grevtsov [5], J. Griffiths [8], A.A. Grillo [138], K. Grimm [74], S. Grinstein [13,s], Ph. Gris [36], J.-F. Grivaz [118], S. Groh [85], E. Gross [176], J. Grosse-Knetter [56], G.C. Grossi [81], Z.J. Grout [80], L. Guan [91], W. Guan [177], J. Guenther [64], F. Guescini [51], D. Guest [167], O. Gueta [156], B. Gui [112], E. Guido [52a,52b], T. Guillemin [5], S. Guindon [2], U. Gul [55], C. Gumpert [32], J. Guo [141], Y. Guo [59,p], R. Gupta [42], S. Gupta [121], G. Gustavino [133a,133b], P. Gutierrez [114], N.G. Gutierrez Ortiz [80], C. Gutschow [46], C. Guyot [137], C. Gwenlan [121], C.B. Gwilliam [76], A. Haas [111], C. Haber [16], H.K. Hadavand [8], N. Haddad [136e], A. Hadef [87], S. Hageböck [23], M. Hagihara [165], Z. Hajduk [41], H. Hakobyan [181,*], M. Haleem [44], J. Haley [115], G. Halladjian [92], G.D. Hallewell [87], K. Hamacher [179], P. Hamal [116], K. Hamano [173], A. Hamilton [148a], G.N. Hamity [142], P.G. Hamnett [44], L. Han [59], K. Hanagaki [68,t], K. Hanawa [158], M. Hance [138], B. Haney [123], P. Hanke [60a], R. Hanna [137], J.B. Hansen [38], J.D. Hansen [38], M.C. Hansen [23], P.H. Hansen [38], K. Hara [165], A.S. Hard [177], T. Harenberg [179], F. Hariri [118], S. Harkusha [94], R.D. Harrington [48], P.F. Harrison [174], F. Hartjes [108], N.M. Hartmann [101], M. Hasegawa [69], Y. Hasegawa [143], A. Hasib [114], S. Hassani [137], S. Haug [18], R. Hauser [92], L. Hauswald [46], M. Havranek [128], C.M. Hawkes [19], R.J. Hawkings [32], D. Hayakawa [160], D. Hayden [92], C.P. Hays [121], J.M. Hays [78], H.S. Hayward [76], S.J. Haywood [132], S.J. Head [19], T. Heck [85], V. Hedberg [83], L. Heelan [8], S. Heim [123], T. Heim [16], B. Heinemann [16], J.J. Heinrich [101], L. Heinrich [111], C. Heinz [54], J. Hejbal [128], L. Helary [32], S. Hellman [149a,149b], C. Helsens [32], J. Henderson [121], R.C.W. Henderson [74], Y. Heng [177], S. Henkelmann [172], A.M. Henriques Correia [32], S. Henrot-Versille [118], G.H. Herbert [17], H. Herde [25], V. Herget [178], Y. Hernández Jiménez [148c], G. Herten [50], R. Hertenberger [101], L. Hervas [32], G.G. Hesketh [80], N.P. Hessey [108], J.W. Hetherly [42], R. Hickling [78], E. Higón-Rodriguez [171], E. Hill [173], J.C. Hill [30], K.H. Hiller [44], S.J. Hillier [19], I. Hinchliffe [16], E. Hines [123], R.R. Hinman [16], M. Hirose [50], D. Hirschbuehl [179], J. Hobbs [151], N. Hod [164a], M.C. Hodgkinson [142], P. Hodgson [142], A. Hoecker [32], M.R. Hoeferkamp [106], F. Hoenig [101], D. Hohn [23], T.R. Holmes [16], M. Homann [45], T. Honda [68], T.M. Hong [126], B.H. Hooberman [170], W.H. Hopkins [117], Y. Horii [104], A.J. Horton [145], J-Y. Hostachy [57], S. Hou [154], A. Hoummada [136a], J. Howarth [44], J. Hoya [73], M. Hrabovsky [116], I. Hristova [17], J. Hrivnac [118], T. Hryn'ova [5], A. Hrynevich [95], C. Hsu [148c], P.J. Hsu [154,u], S.-C. Hsu [139], Q. Hu [59], S. Hu [141], Y. Huang [44], Z. Hubacek [129], F. Hubaut [87], F. Huegging [23], T.B. Huffman [121], E.W. Hughes [37], G. Hughes [74], M. Huhtinen [32], P. Huo [151], N. Huseynov [67,b], J. Huston [92], J. Huth [58], G. Iacobucci [51], G. Iakovidis [27], I. Ibragimov [144], L. Iconomidou-Fayard [118], E. Ideal [180], Z. Idrissi [136e], P. Iengo [32], O. Igonkina [108,v], T. Iizawa [175], Y. Ikegami [68], M. Ikeno [68], Y. Ilchenko [11,w], D. Iliadis [157], N. Ilic [146], T. Ince [102], G. Introzzi [122a,122b], P. Ioannou [9,∗], M. Iodice [135a], K. Iordanidou [37], V. Ippolito [58], N. Ishijima [119], M. Ishino [158], M. Ishitsuka [160], R. Ishmukhametov [112], C. Issever [121], S. Istin [20a], F. Ito [165], J.M. Iturbe Ponce [86], R. Iuppa [163a,163b], W. Iwanski [64], H. Iwasaki [68], J.M. Izen [43], V. Izzo [105a], S. Jabbar [3], B. Jackson [123], P. Jackson [1], V. Jain [2], K.B. Jakobi [85], K. Jakobs [50], S. Jakobsen [32], T. Jakoubek [128], D.O. Jamin [115], D.K. Jana [81], R. Jansky [64], J. Janssen [23], M. Janus [56], G. Jarlskog [83], N. Javadov [67,b], T. Javůrek [50], F. Jeanneau [137], L. Jeanty [16], G.-Y. Jeng [153], D. Jennens [90], P. Jenni [50,x], C. Jeske [174], S. Jézéquel [5], H. Ji [177], J. Jia [151], H. Jiang [66], Y. Jiang [59], Z. Jiang [146], S. Jiggins [80], J. Jimenez Pena [171], S. Jin [35a], A. Jinaru [28b], O. Jinnouchi [160], H. Jivan [148c], P. Johansson [142], K.A. Johns [7], W.J. Johnson [139], K. Jon-And [149a,149b], G. Jones [174], R.W.L. Jones [74], S. Jones [7], T.J. Jones [76], J. Jongmanns [60a], P.M. Jorge [127a,127b], J. Jovicevic [164a], X. Ju [177], A. Juste Rozas [13,s], M.K. Köhler [176], A. Kaczmarska [41], M. Kado [118], H. Kagan [112], M. Kagan [146], S.J. Kahn [87], T. Kaji [175], E. Kajomovitz [47], C.W. Kalderon [121], A. Kaluza [85], S. Kama [42], A. Kamenshchikov [131], N. Kanaya [158], S. Kaneti [30], L. Kanjir [77], V.A. Kantserov [99], J. Kanzaki [68], B. Kaplan [111], L.S. Kaplan [177], A. Kapliy [33], D. Kar [148c], K. Karakostas [10], A. Karamaoun [3], N. Karastathis [10], M.J. Kareem [56], E. Karentzos [10], M. Karnevskiy [85], S.N. Karpov [67], Z.M. Karpova [67], K. Karthik [111], V. Kartvelishvili [74], A.N. Karyukhin [131], K. Kasahara [165], L. Kashif [177], R.D. Kass [112], A. Kastanas [150], Y. Kataoka [158], C. Kato [158], A. Katre [51], J. Katzy [44], K. Kawade [104], K. Kawagoe [72], T. Kawamoto [158], G. Kawamura [56], V.F. Kazanin [110,c], R. Keeler [173], R. Kehoe [42], J.S. Keller [44], J.J. Kempster [79], H. Keoshkerian [162], O. Kepka [128], B.P. Kerševan [77], S. Kersten [179], R.A. Keyes [89], M. Khader [170], F. Khalil-zada [12], A. Khanov [115], A.G. Kharlamov [110,c], T. Kharlamova [110], T.J. Khoo [51], V. Khovanskiy [98], E. Khramov [67], J. Khubua [53b,y], S. Kido [69], C.R. Kilby [79], H.Y. Kim [8], S.H. Kim [165], Y.K. Kim [33], N. Kimura [157], O.M. Kind [17], B.T. King [76], M. King [171], J. Kirk [132], A.E. Kiryunin [102], T. Kishimoto [158], D. Kisielewska [40a], F. Kiss [50], K. Kiuchi [165], O. Kivernyk [137], E. Kladiva [147b], M.H. Klein [37], M. Klein [76], U. Klein [76], K. Kleinknecht [85], P. Klimek [109], A. Klimentov [27], R. Klingenberg [45], J.A. Klinger [142], T. Klioutchnikova [32], E.-E. Kluge [60a], P. Kluit [108], S. Kluth [102], J. Knapik [41], E. Kneringer [64], E.B.F.G. Knoops [87], A. Knue [55], A. Kobayashi [158], D. Kobayashi [160], T. Kobayashi [158], M. Kobel [46], M. Kocian [146], P. Kodys [130], N.M. Koehler [102], T. Koffas [31], E. Koffeman [108], T. Koi [146], H. Kolanoski [17], M. Kolb [60b], I. Koletsou [5], A.A. Komar [97,∗], Y. Komori [158], T. Kondo [68], N. Kondrashova [44], K. Köneke [50], A.C. König [107], T. Kono [68,z], R. Konoplich [111,aa], N. Konstantinidis [80], R. Kopeliansky [63], S. Koperny [40a], L. Köpke [85], A.K. Kopp [50], K. Korcyl [41], K. Kordas [157], A. Korn [80], A.A. Korol [110,c], I. Korolkov [13], E.V. Korolkova [142], O. Kortner [102], S. Kortner [102], T. Kosek [130], V.V. Kostyukhin [23], A. Kotwal [47], A. Koulouris [10], A. Kourkoumeli-Charalampidi [122a,122b], C. Kourkoumelis [9], V. Kouskoura [27], A.B. Kowalewska [41], R. Kowalewski [173], T.Z. Kowalski [40a], C. Kozakai [158], W. Kozanecki [137], A.S. Kozhin [131], V.A. Kramarenko [100], G. Kramberger [77], D. Krasnopevtsev [99], M.W. Krasny [82], A. Krasznahorkay [32], A. Kravchenko [27], M. Kretz [60c], J. Kretzschmar [76], K. Kreutzfeldt [54], P. Krieger [162], K. Krizka [33], K. Kroeninger [45], H. Kroha [102], J. Kroll [123], J. Kroseberg [23], J. Krstic [14], U. Kruchonak [67], H. Krüger [23], N. Krumnack [66], M.C. Kruse [47], M. Kruskal [24], T. Kubota [90], H. Kucuk [80], S. Kuday [4b], J.T. Kuechler [179], S. Kuehn [50], A. Kugel [60c], F. Kuger [178], A. Kuhl [138], T. Kuhl [44], V. Kukhtin [67], R. Kukla [137], Y. Kulchitsky [94], S. Kuleshov [34b], M. Kuna [133a,133b], T. Kunigo [70], A. Kupco [128], H. Kurashige [69], Y.A. Kurochkin [94], V. Kus [128], E.S. Kuwertz [173], M. Kuze [160], J. Kvita [116], T. Kwan [173], D. Kyriazopoulos [142], A. La Rosa [102], J.L. La Rosa Navarro [26d], L. La Rotonda [39a,39b], C. Lacasta [171], F. Lacava [133a,133b], J. Lacey [31], H. Lacker [17], D. Lacour [82], V.R. Lacuesta [171], E. Ladygin [67], R. Lafaye [5], B. Laforge [82], T. Lagouri [180], S. Lai [56], S. Lammers [63], W. Lampl [7], E. Lançon [137], U. Landgraf [50], M.P.J. Landon [78], M.C. Lanfermann [51], V.S. Lang [60a], J.C. Lange [13], A.J. Lankford [167], F. Lanni [27], K. Lantzsch [23], A. Lanza [122a], S. Laplace [82], C. Lapoire [32], J.F. Laporte [137], T. Lari [93a], F. Lasagni Manghi [22a,22b], M. Lassnig [32], P. Laurelli [49], W. Lavrijsen [16], A.T. Law [138], P. Laycock [76], T. Lazovich [58], M. Lazzaroni [93a,93b], B. Le [90], O. Le Dortz [82], E. Le Guirriec [87], E.P. Le Quilleuc [137], M. LeBlanc [173], T. LeCompte [6], F. Ledroit-Guillon [57], C.A. Lee [27], S.C. Lee [154], L. Lee [1], B. Lefebvre [89], G. Lefebvre [82], M. Lefebvre [173], F. Legger [101], C. Leggett [16], A. Lehan [76], G. Lehmann Miotto [32], X. Lei [7], W.A. Leight [31], A.G. Leister [180], M.A.L. Leite [26d], R. Leitner [130],

D. Lellouch [176], B. Lemmer [56], K.J.C. Leney [80], T. Lenz [23], B. Lenzi [32], R. Leone [7], S. Leone [125a,125b], C. Leonidopoulos [48], S. Leontsinis [10], G. Lerner [152], C. Leroy [96], A.A.J. Lesage [137], C.G. Lester [30], M. Levchenko [124], J. Levêque [5], D. Levin [91], L.J. Levinson [176], M. Levy [19], D. Lewis [78], A.M. Leyko [23], M. Leyton [43], B. Li [59,p], C. Li [59], H. Li [151], H.L. Li [33], L. Li [47], L. Li [141], Q. Li [35a], S. Li [47], X. Li [86], Y. Li [144], Z. Liang [35a], B. Liberti [134a], A. Liblong [162], P. Lichard [32], K. Lie [170], J. Liebal [23], W. Liebig [15], A. Limosani [153], S.C. Lin [154,ab], T.H. Lin [85], B.E. Lindquist [151], A.E. Lionti [51], E. Lipeles [123], A. Lipniacka [15], M. Lisovyi [60b], T.M. Liss [170], A. Lister [172], A.M. Litke [138], B. Liu [154,ac], D. Liu [154], H. Liu [91], H. Liu [27], J. Liu [87], J.B. Liu [59], K. Liu [87], L. Liu [170], M. Liu [47], M. Liu [59], Y.L. Liu [59], Y. Liu [59], M. Livan [122a,122b], A. Lleres [57], J. Llorente Merino [35a], S.L. Lloyd [78], F. Lo Sterzo [154], E.M. Lobodzinska [44], P. Loch [7], F.K. Loebinger [86], K.M. Loew [25], A. Loginov [180,*], T. Lohse [17], K. Lohwasser [44], M. Lokajicek [128], B.A. Long [24], J.D. Long [170], R.E. Long [74], L. Longo [75a,75b], K.A. Looper [112], J.A. López [34b], D. Lopez Mateos [58], B. Lopez Paredes [142], I. Lopez Paz [13], A. Lopez Solis [82], J. Lorenz [101], N. Lorenzo Martinez [63], M. Losada [21], P.J. Lösel [101], X. Lou [35a], A. Lounis [118], J. Love [6], P.A. Love [74], H. Lu [62a], N. Lu [91], H.J. Lubatti [139], C. Luci [133a,133b], A. Lucotte [57], C. Luedtke [50], F. Luehring [63], W. Lukas [64], L. Luminari [133a], O. Lundberg [149a,149b], B. Lund-Jensen [150], P.M. Luzi [82], D. Lynn [27], R. Lysak [128], E. Lytken [83], V. Lyubushkin [67], H. Ma [27], L.L. Ma [140], Y. Ma [140], G. Maccarrone [49], A. Macchiolo [102], C.M. Macdonald [142], B. Maček [77], J. Machado Miguens [123,127b], D. Madaffari [87], R. Madar [36], H.J. Maddocks [169], W.F. Mader [46], A. Madsen [44], J. Maeda [69], S. Maeland [15], T. Maeno [27], A. Maevskiy [100], E. Magradze [56], J. Mahlstedt [108], C. Maiani [118], C. Maidantchik [26a], A.A. Maier [102], T. Maier [101], A. Maio [127a,127b,127d], S. Majewski [117], Y. Makida [68], N. Makovec [118], B. Malaescu [82], Pa. Malecki [41], V.P. Maleev [124], F. Malek [57], U. Mallik [65], D. Malon [6], C. Malone [146], C. Malone [30], S. Maltezos [10], S. Malyukov [32], J. Mamuzic [171], G. Mancini [49], L. Mandelli [93a], I. Mandić [77], J. Maneira [127a,127b], L. Manhaes de Andrade Filho [26b], J. Manjarres Ramos [164b], A. Mann [101], A. Manousos [32], B. Mansoulie [137], J.D. Mansour [35a], R. Mantifel [89], M. Mantoani [56], S. Manzoni [93a,93b], L. Mapelli [32], G. Marceca [29], L. March [51], G. Marchiori [82], M. Marcisovsky [128], M. Marjanovic [14], D.E. Marley [91], F. Marroquim [26a], S.P. Marsden [86], Z. Marshall [16], S. Marti-Garcia [171], B. Martin [92], T.A. Martin [174], V.J. Martin [48], B. Martin dit Latour [15], M. Martinez [13,s], V.I. Martinez Outschoorn [170], S. Martin-Haugh [132], V.S. Martoiu [28b], A.C. Martyniuk [80], A. Marzin [32], L. Masetti [85], T. Mashimo [158], R. Mashinistov [97], J. Masik [86], A.L. Maslennikov [110,c], I. Massa [22a,22b], L. Massa [22a,22b], P. Mastrandrea [5], A. Mastroberardino [39a,39b], T. Masubuchi [158], P. Mättig [179], J. Mattmann [85], J. Maurer [28b], S.J. Maxfield [76], D.A. Maximov [110,c], R. Mazini [154], I. Maznas [157], S.M. Mazza [93a,93b], N.C. Mc Fadden [106], G. Mc Goldrick [162], S.P. Mc Kee [91], A. McCarn [91], R.L. McCarthy [151], T.G. McCarthy [102], L.I. McClymont [80], E.F. McDonald [90], J.A. Mcfayden [80], G. Mchedlidze [56], S.J. McMahon [132], R.A. McPherson [173,m], M. Medinnis [44], S. Meehan [139], S. Mehlhase [101], A. Mehta [76], K. Meier [60a], C. Meineck [101], B. Meirose [43], D. Melini [171], B.R. Mellado Garcia [148c], M. Melo [147a], F. Meloni [18], X. Meng [91], A. Mengarelli [22a,22b], S. Menke [102], E. Meoni [166], S. Mergelmeyer [17], P. Mermod [51], L. Merola [105a,105b], C. Meroni [93a], F.S. Merritt [33], A. Messina [133a,133b], J. Metcalfe [6], A.S. Mete [167], C. Meyer [85], C. Meyer [123], J-P. Meyer [137], J. Meyer [108], H. Meyer Zu Theenhausen [60a], F. Miano [152], R.P. Middleton [132], S. Miglioranzi [52a,52b], L. Mijović [48], G. Mikenberg [176], M. Mikestikova [128], M. Mikuž [77], M. Milesi [90], A. Milic [64], D.W. Miller [33], C. Mills [48], A. Milov [176], D.A. Milstead [149a,149b], A.A. Minaenko [131], Y. Minami [158], I.A. Minashvili [67], A.I. Mincer [111], B. Mindur [40a], M. Mineev [67], Y. Minegishi [158], Y. Ming [177], L.M. Mir [13], K.P. Mistry [123], T. Mitani [175], J. Mitrevski [101], V.A. Mitsou [171], A. Miucci [18], P.S. Miyagawa [142], J.U. Mjörnmark [83], M. Mlynarikova [130], T. Moa [149a,149b], K. Mochizuki [96], S. Mohapatra [37], S. Molander [149a,149b], R. Moles-Valls [23], R. Monden [70], M.C. Mondragon [92], K. Mönig [44], J. Monk [38], E. Monnier [87], A. Montalbano [151], J. Montejo Berlingen [32], F. Monticelli [73], S. Monzani [93a,93b], R.W. Moore [3], N. Morange [118], D. Moreno [21], M. Moreno Llácer [56], P. Morettini [52a], S. Morgenstern [32], D. Mori [145], T. Mori [158], M. Morii [58], M. Morinaga [158], V. Morisbak [120], S. Moritz [85], A.K. Morley [153], G. Mornacchi [32], J.D. Morris [78], S.S. Mortensen [38], L. Morvaj [151], M. Mosidze [53b], J. Moss [146,ad], K. Motohashi [160], R. Mount [146], E. Mountricha [27], E.J.W. Moyse [88], S. Muanza [87], R.D. Mudd [19], F. Mueller [102], J. Mueller [126], R.S.P. Mueller [101], T. Mueller [30], D. Muenstermann [74], P. Mullen [55], G.A. Mullier [18], F.J. Munoz Sanchez [86], J.A. Murillo Quijada [19], W.J. Murray [174,132], H. Musheghyan [56], M. Muškinja [77], A.G. Myagkov [131,ae], M. Myska [129], B.P. Nachman [146], O. Nackenhorst [51], K. Nagai [121], R. Nagai [68,z], K. Nagano [68], Y. Nagasaka [61], K. Nagata [165], M. Nagel [50], E. Nagy [87], A.M. Nairz [32], Y. Nakahama [104], K. Nakamura [68], T. Nakamura [158],

I. Nakano [113], R.F. Naranjo Garcia [44], R. Narayan [11], D.I. Narrias Villar [60a], I. Naryshkin [124], T. Naumann [44], G. Navarro [21], R. Nayyar [7], H.A. Neal [91], P.Yu. Nechaeva [97], T.J. Neep [86], A. Negri [122a,122b], M. Negrini [22a], S. Nektarijevic [107], C. Nellist [118], A. Nelson [167], S. Nemecek [128], P. Nemethy [111], A.A. Nepomuceno [26a], M. Nessi [32,af], M.S. Neubauer [170], M. Neumann [179], R.M. Neves [111], P. Nevski [27], P.R. Newman [19], D.H. Nguyen [6], T. Nguyen Manh [96], R.B. Nickerson [121], R. Nicolaidou [137], J. Nielsen [138], A. Nikiforov [17], V. Nikolaenko [131,ae], I. Nikolic-Audit [82], K. Nikolopoulos [19], J.K. Nilsen [120], P. Nilsson [27], Y. Ninomiya [158], A. Nisati [133a], R. Nisius [102], T. Nobe [158], M. Nomachi [119], I. Nomidis [31], T. Nooney [78], S. Norberg [114], M. Nordberg [32], N. Norjoharuddeen [121], O. Novgorodova [46], S. Nowak [102], M. Nozaki [68], L. Nozka [116], K. Ntekas [167], E. Nurse [80], F. Nuti [90], F. O'grady [7], D.C. O'Neil [145], A.A. O'Rourke [44], V. O'Shea [55], F.G. Oakham [31,d], H. Oberlack [102], T. Obermann [23], J. Ocariz [82], A. Ochi [69], I. Ochoa [37], J.P. Ochoa-Ricoux [34a], S. Oda [72], S. Odaka [68], H. Ogren [63], A. Oh [86], S.H. Oh [47], C.C. Ohm [16], H. Ohman [169], H. Oide [52a,52b], H. Okawa [165], Y. Okumura [158], T. Okuyama [68], A. Olariu [28b], L.F. Oleiro Seabra [127a], S.A. Olivares Pino [48], D. Oliveira Damazio [27], A. Olszewski [41], J. Olszowska [41], A. Onofre [127a,127e], K. Onogi [104], P.U.E. Onyisi [11,w], M.J. Oreglia [33], Y. Oren [156], D. Orestano [135a,135b], N. Orlando [62b], R.S. Orr [162], B. Osculati [52a,52b,*], R. Ospanov [86], G. Otero y Garzon [29], H. Otono [72], M. Ouchrif [136d], F. Ould-Saada [120], A. Ouraou [137], K.P. Oussoren [108], Q. Ouyang [35a], M. Owen [55], R.E. Owen [19], V.E. Ozcan [20a], N. Ozturk [8], K. Pachal [145], A. Pacheco Pages [13], L. Pacheco Rodriguez [137], C. Padilla Aranda [13], M. Pagáčová [50], S. Pagan Griso [16], M. Paganini [180], F. Paige [27], P. Pais [88], K. Pajchel [120], G. Palacino [164b], S. Palazzo [39a,39b], S. Palestini [32], M. Palka [40b], D. Pallin [36], E. St. Panagiotopoulou [10], C.E. Pandini [82], J.G. Panduro Vazquez [79], P. Pani [149a,149b], S. Panitkin [27], D. Pantea [28b], L. Paolozzi [51], Th.D. Papadopoulou [10], K. Papageorgiou [157], A. Paramonov [6], D. Paredes Hernandez [180], A.J. Parker [74], M.A. Parker [30], K.A. Parker [142], F. Parodi [52a,52b], J.A. Parsons [37], U. Parzefall [50], V.R. Pascuzzi [162], E. Pasqualucci [133a], S. Passaggio [52a], Fr. Pastore [79], G. Pásztor [31,ag], S. Pataraia [179], J.R. Pater [86], T. Pauly [32], J. Pearce [173], B. Pearson [114], L.E. Pedersen [38], M. Pedersen [120], S. Pedraza Lopez [171], R. Pedro [127a,127b], S.V. Peleganchuk [110,c], O. Penc [128], C. Peng [35a], H. Peng [59], J. Penwell [63], B.S. Peralva [26b], M.M. Perego [137], D.V. Perepelitsa [27], E. Perez Codina [164a], L. Perini [93a,93b], H. Pernegger [32], S. Perrella [105a,105b], R. Peschke [44], V.D. Peshekhonov [67], K. Peters [44], R.F.Y. Peters [86], B.A. Petersen [32], T.C. Petersen [38], E. Petit [57], A. Petridis [1], C. Petridou [157], P. Petroff [118], E. Petrolo [133a], M. Petrov [121], F. Petrucci [135a,135b], N.E. Pettersson [88], A. Peyaud [137], R. Pezoa [34b], P.W. Phillips [132], G. Piacquadio [146,ah], E. Pianori [174], A. Picazio [88], E. Piccaro [78], M. Piccinini [22a,22b], M.A. Pickering [121], R. Piegaia [29], J.E. Pilcher [33], A.D. Pilkington [86], A.W.J. Pin [86], M. Pinamonti [168a,168c,ai], J.L. Pinfold [3], A. Pingel [38], S. Pires [82], H. Pirumov [44], M. Pitt [176], L. Plazak [147a], M.-A. Pleier [27], V. Pleskot [85], E. Plotnikova [67], P. Plucinski [92], D. Pluth [66], R. Poettgen [149a,149b], L. Poggioli [118], D. Pohl [23], G. Polesello [122a], A. Poley [44], A. Policicchio [39a,39b], R. Polifka [162], A. Polini [22a], C.S. Pollard [55], V. Polychronakos [27], K. Pommès [32], L. Pontecorvo [133a], B.G. Pope [92], G.A. Popeneciu [28c], A. Poppleton [32], S. Pospisil [129], K. Potamianos [16], I.N. Potrap [67], C.J. Potter [30], C.T. Potter [117], G. Poulard [32], J. Poveda [32], V. Pozdnyakov [67], M.E. Pozo Astigarraga [32], P. Pralavorio [87], A. Pranko [16], S. Prell [66], D. Price [86], L.E. Price [6], M. Primavera [75a], S. Prince [89], K. Prokofiev [62c], F. Prokoshin [34b], S. Protopopescu [27], J. Proudfoot [6], M. Przybycien [40a], D. Puddu [135a,135b], M. Purohit [27,aj], P. Puzo [118], J. Qian [91], G. Qin [55], Y. Qin [86], A. Quadt [56], W.B. Quayle [168a,168b], M. Queitsch-Maitland [44], D. Quilty [55], S. Raddum [120], V. Radeka [27], V. Radescu [121], S.K. Radhakrishnan [151], P. Radloff [117], P. Rados [90], F. Ragusa [93a,93b], G. Rahal [182], J.A. Raine [86], S. Rajagopalan [27], M. Rammensee [32], C. Rangel-Smith [169], M.G. Ratti [93a,93b], D.M. Rauch [44], F. Rauscher [101], S. Rave [85], T. Ravenscroft [55], I. Ravinovich [176], M. Raymond [32], A.L. Read [120], N.P. Readioff [76], M. Reale [75a,75b], D.M. Rebuzzi [122a,122b], A. Redelbach [178], G. Redlinger [27], R. Reece [138], R.G. Reed [148c], K. Reeves [43], L. Rehnisch [17], J. Reichert [123], A. Reiss [85], C. Rembser [32], H. Ren [35a], M. Rescigno [133a], S. Resconi [93a], O.L. Rezanova [110,c], P. Reznicek [130], R. Rezvani [96], R. Richter [102], S. Richter [80], E. Richter-Was [40b], O. Ricken [23], M. Ridel [82], P. Rieck [17], C.J. Riegel [179], J. Rieger [56], O. Rifki [114], M. Rijssenbeek [151], A. Rimoldi [122a,122b], M. Rimoldi [18], L. Rinaldi [22a], B. Ristić [51], E. Ritsch [32], I. Riu [13], F. Rizatdinova [115], E. Rizvi [78], C. Rizzi [13], S.H. Robertson [89,m], A. Robichaud-Veronneau [89], D. Robinson [30], J.E.M. Robinson [44], A. Robson [55], C. Roda [125a,125b], Y. Rodina [87,ak], A. Rodriguez Perez [13], D. Rodriguez Rodriguez [171], S. Roe [32], C.S. Rogan [58], O. Røhne [120], J. Roloff [58], A. Romaniouk [99], M. Romano [22a,22b], S.M. Romano Saez [36], E. Romero Adam [171], N. Rompotis [139], M. Ronzani [50], L. Roos [82], E. Ros [171], S. Rosati [133a], K. Rosbach [50], P. Rose [138], N.-A. Rosien [56], V. Rossetti [149a,149b], E. Rossi [105a,105b], L.P. Rossi [52a], J.H.N. Rosten [30], R. Rosten [139], M. Rotaru [28b], I. Roth [176], J. Rothberg [139], D. Rousseau [118], A. Rozanov [87], Y. Rozen [155], X. Ruan [148c], F. Rubbo [146], M.S. Rudolph [162], F. Rühr [50], A. Ruiz-Martinez [31], Z. Rurikova [50], N.A. Rusakovich [67], A. Ruschke [101], H.L. Russell [139], J.P. Rutherfoord [7], N. Ruthmann [32], Y.F. Ryabov [124], M. Rybar [170], G. Rybkin [118], S. Ryu [6], A. Ryzhov [131], G.F. Rzehorz [56], A.F. Saavedra [153], G. Sabato [108], S. Sacerdoti [29], H.F-W. Sadrozinski [138], R. Sadykov [67], F. Safai Tehrani [133a], P. Saha [109], M. Sahinsoy [60a], M. Saimpert [137], T. Saito [158], H. Sakamoto [158], Y. Sakurai [175], G. Salamanna [135a,135b], A. Salamon [134a,134b], J.E. Salazar Loyola [34b], D. Salek [108], P.H. Sales De Bruin [139], D. Salihagic [102], A. Salnikov [146], J. Salt [171], D. Salvatore [39a,39b], F. Salvatore [152], A. Salvucci [62a,62b,62c], A. Salzburger [32], D. Sammel [50], D. Sampsonidis [157], J. Sánchez [171], V. Sanchez Martinez [171], A. Sanchez Pineda [105a,105b], H. Sandaker [120], R.L. Sandbach [78], M. Sandhoff [179], C. Sandoval [21], D.P.C. Sankey [132], M. Sannino [52a,52b], A. Sansoni [49], C. Santoni [36], R. Santonico [134a,134b], H. Santos [127a], I. Santoyo Castillo [152], K. Sapp [126], A. Sapronov [67], J.G. Saraiva [127a,127d], B. Sarrazin [23], O. Sasaki [68], K. Sato [165], E. Sauvan [5], G. Savage [79], P. Savard [162,d], N. Savic [102], C. Sawyer [132], L. Sawyer [81,r], J. Saxon [33], C. Sbarra [22a], A. Sbrizzi [22a,22b], T. Scanlon [80], D.A. Scannicchio [167], M. Scarcella [153], V. Scarfone [39a,39b], J. Schaarschmidt [176], P. Schacht [102], B.M. Schachtner [101], D. Schaefer [32], L. Schaefer [123], R. Schaefer [44], J. Schaeffer [85], S. Schaepe [23], S. Schaetzel [60b], U. Schäfer [85], A.C. Schaffer [118], D. Schaile [101], R.D. Schamberger [151], V. Scharf [60a], V.A. Schegelsky [124], D. Scheirich [130], M. Schernau [167], C. Schiavi [52a,52b], S. Schier [138], C. Schillo [50], M. Schioppa [39a,39b], S. Schlenker [32], K.R. Schmidt-Sommerfeld [102], K. Schmieden [32], C. Schmitt [85], S. Schmitt [44], S. Schmitz [85], B. Schneider [164a], U. Schnoor [50], L. Schoeffel [137], A. Schoening [60b], B.D. Schoenrock [92], E. Schopf [23], M. Schott [85], J.F.P. Schouwenberg [107], J. Schovancova [8], S. Schramm [51], M. Schreyer [178], N. Schuh [85], A. Schulte [85], M.J. Schultens [23], H.-C. Schultz-Coulon [60a], H. Schulz [17], M. Schumacher [50], B.A. Schumm [138], Ph. Schune [137], A. Schwartzman [146], T.A. Schwarz [91], H. Schweiger [86], Ph. Schwemling [137], R. Schwienhorst [92], J. Schwindling [137], T. Schwindt [23], G. Sciolla [25], F. Scuri [125a,125b], F. Scutti [90], J. Searcy [91], P. Seema [23], S.C. Seidel [106], A. Seiden [138], F. Seifert [129], J.M. Seixas [26a], G. Sekhniaidze [105a], K. Sekhon [91], S.J. Sekula [42], D.M. Seliverstov [124,*], N. Semprini-Cesari [22a,22b], C. Serfon [120], L. Serin [118], L. Serkin [168a,168b], M. Sessa [135a,135b], R. Seuster [173], H. Severini [114], T. Sfiligoj [77], F. Sforza [32], A. Sfyrla [51], E. Shabalina [56], N.W. Shaikh [149a,149b], L.Y. Shan [35a], R. Shang [170], J.T. Shank [24], M. Shapiro [16], P.B. Shatalov [98], K. Shaw [168a,168b], S.M. Shaw [86], A. Shcherbakova [149a,149b], C.Y. Shehu [152], P. Sherwood [80], L. Shi [154,al], S. Shimizu [69], C.O. Shimmin [167], M. Shimojima [103], S. Shirabe [72], M. Shiyakova [67,am], A. Shmeleva [97], D. Shoaleh Saadi [96], M.J. Shochet [33], S. Shojaii [93a,93b], D.R. Shope [114], S. Shrestha [112], E. Shulga [99], M.A. Shupe [7], P. Sicho [128], A.M. Sickles [170], P.E. Sidebo [150], E. Sideras Haddad [148c], O. Sidiropoulou [178], D. Sidorov [115], A. Sidoti [22a,22b], F. Siegert [46], Dj. Sijacki [14], J. Silva [127a,127d], S.B. Silverstein [149a], V. Simak [129], Lj. Simic [14], S. Simion [118], E. Simioni [85], B. Simmons [80], D. Simon [36], M. Simon [85], P. Sinervo [162], N.B. Sinev [117], M. Sioli [22a,22b], G. Siragusa [178], S.Yu. Sivoklokov [100], J. Sjölin [149a,149b], M.B. Skinner [74], H.P. Skottowe [58], P. Skubic [114], M. Slater [19], T. Slavicek [129], M. Slawinska [108], K. Sliwa [166], R. Slovak [130], V. Smakhtin [176], B.H. Smart [5], L. Smestad [15], J. Smiesko [147a], S.Yu. Smirnov [99], Y. Smirnov [99], L.N. Smirnova [100,an], O. Smirnova [83], M.N.K. Smith [37], R.W. Smith [37], M. Smizanska [74], K. Smolek [129], A.A. Snesarev [97], I.M. Snyder [117], S. Snyder [27], R. Sobie [173,m], F. Socher [46], A. Soffer [156], D.A. Soh [154], G. Sokhrannyi [77], C.A. Solans Sanchez [32], M. Solar [129], E.Yu. Soldatov [99], U. Soldevila [171], A.A. Solodkov [131], A. Soloshenko [67], O.V. Solovyanov [131], V. Solovyev [124], P. Sommer [50], H. Son [166], H.Y. Song [59,ao], A. Sood [16], A. Sopczak [129], V. Sopko [129], V. Sorin [13], D. Sosa [60b], C.L. Sotiropoulou [125a,125b], R. Soualah [168a,168c], A.M. Soukharev [110,c], D. South [44], B.C. Sowden [79], S. Spagnolo [75a,75b], M. Spalla [125a,125b], M. Spangenberg [174], M. Spannowsky [ap], F. Spanò [79], D. Sperlich [17], F. Spettel [102], R. Spighi [22a], G. Spigo [32], L.A. Spiller [90], M. Spousta [130], R.D. St. Denis [55,*], A. Stabile [93a], R. Stamen [60a], S. Stamm [17], E. Stanecka [41], R.W. Stanek [6], C. Stanescu [135a], M. Stanescu-Bellu [44], M.M. Stanitzki [44], S. Stapnes [120], E.A. Starchenko [131], G.H. Stark [33], J. Stark [57], P. Staroba [128], P. Starovoitov [60a], S. Stärz [32], R. Staszewski [41], P. Steinberg [27], B. Stelzer [145], H.J. Stelzer [32], O. Stelzer-Chilton [164a], H. Stenzel [54], G.A. Stewart [55], J.A. Stillings [23], M.C. Stockton [89], M. Stoebe [89], G. Stoicea [28b], P. Stolte [56], S. Stonjek [102], A.R. Stradling [8], A. Straessner [46], M.E. Stramaglia [18], J. Strandberg [150], S. Strandberg [149a,149b], A. Strandlie [120], M. Strauss [114], P. Strizenec [147b], R. Ströhmer [178], D.M. Strom [117], R. Stroynowski [42], A. Strubig [107], S.A. Stucci [27], B. Stugu [15], N.A. Styles [44], D. Su [146], J. Su [126], S. Suchek [60a], Y. Sugaya [119], M. Suk [129], V.V. Sulin [97], S. Sultansoy [4c], T. Sumida [70], S. Sun [58],

X. Sun [35a], J.E. Sundermann [50], K. Suruliz [152], G. Susinno [39a,39b], M.R. Sutton [152], S. Suzuki [68], M. Svatos [128], M. Swiatlowski [33], I. Sykora [147a], T. Sykora [130], D. Ta [50], C. Taccini [135a,135b], K. Tackmann [44], J. Taenzer [162], A. Taffard [167], R. Tafirout [164a], N. Taiblum [156], H. Takai [27], R. Takashima [71], T. Takeshita [143], Y. Takubo [68], M. Talby [87], A.A. Talyshev [110,c], K.G. Tan [90], J. Tanaka [158], M. Tanaka [160], R. Tanaka [118], S. Tanaka [68], R. Tanioka [69], B.B. Tannenwald [112], S. Tapia Araya [34b], S. Tapprogge [85], S. Tarem [155], G.F. Tartarelli [93a], P. Tas [130], M. Tasevsky [128], T. Tashiro [70], E. Tassi [39a,39b], A. Tavares Delgado [127a,127b], Y. Tayalati [136e], A.C. Taylor [106], G.N. Taylor [90], P.T.E. Taylor [90], W. Taylor [164b], F.A. Teischinger [32], P. Teixeira-Dias [79], K.K. Temming [50], D. Temple [145], H. Ten Kate [32], P.K. Teng [154], J.J. Teoh [119], F. Tepel [179], S. Terada [68], K. Terashi [158], J. Terron [84], S. Terzo [13], M. Testa [49], R.J. Teuscher [162,m], T. Theveneaux-Pelzer [87], J.P. Thomas [19], J. Thomas-Wilsker [79], P.D. Thompson [19], A.S. Thompson [55], L.A. Thomsen [180], E. Thomson [123], M.J. Tibbetts [16], R.E. Ticse Torres [87], V.O. Tikhomirov [97,aq], Yu.A. Tikhonov [110,c], S. Timoshenko [99], P. Tipton [180], S. Tisserant [87], K. Todome [160], T. Todorov [5,*], S. Todorova-Nova [130], J. Tojo [72], S. Tokár [147a], K. Tokushuku [68], E. Tolley [58], L. Tomlinson [86], M. Tomoto [104], L. Tompkins [146,ar], K. Toms [106], B. Tong [58], P. Tornambe [50], E. Torrence [117], H. Torres [145], E. Torró Pastor [139], J. Toth [87,as], F. Touchard [87], D.R. Tovey [142], T. Trefzger [178], A. Tricoli [27], I.M. Trigger [164a], S. Trincaz-Duvoid [82], M.F. Tripiana [13], W. Trischuk [162], B. Trocmé [57], A. Trofymov [44], C. Troncon [93a], M. Trottier-McDonald [16], M. Trovatelli [173], L. Truong [168a,168c], M. Trzebinski [41], A. Trzupek [41], J.C-L. Tseng [121], P.V. Tsiareshka [94], G. Tsipolitis [10], N. Tsirintanis [9], S. Tsiskaridze [13], V. Tsiskaridze [50], E.G. Tskhadadze [53a], K.M. Tsui [62a], I.I. Tsukerman [98], V. Tsulaia [16], S. Tsuno [68], D. Tsybychev [151], Y. Tu [62b], A. Tudorache [28b], V. Tudorache [28b], A.N. Tuna [58], S.A. Tupputi [22a,22b], S. Turchikhin [67], D. Turecek [129], D. Turgeman [176], R. Turra [93a,93b], P.M. Tuts [37], M. Tyndel [132], G. Ucchielli [22a,22b], I. Ueda [158], M. Ughetto [149a,149b], F. Ukegawa [165], G. Unal [32], A. Undrus [27], G. Unel [167], F.C. Ungaro [90], Y. Unno [68], C. Unverdorben [101], J. Urban [147b], P. Urquijo [90], P. Urrejola [85], G. Usai [8], J. Usui [68], L. Vacavant [87], V. Vacek [129], B. Vachon [89], C. Valderanis [101], E. Valdes Santurio [149a,149b], N. Valencic [108], S. Valentinetti [22a,22b], A. Valero [171], L. Valery [13], S. Valkar [130], J.A. Valls Ferrer [171], W. Van Den Wollenberg [108], P.C. Van Der Deijl [108], H. van der Graaf [108], N. van Eldik [155], P. van Gemmeren [6], J. Van Nieuwkoop [145], I. van Vulpen [108], M.C. van Woerden [108], M. Vanadia [133a,133b], W. Vandelli [32], R. Vanguri [123], A. Vaniachine [161], P. Vankov [108], G. Vardanyan [181], R. Vari [133a], E.W. Varnes [7], T. Varol [42], D. Varouchas [82], A. Vartapetian [8], K.E. Varvell [153], J.G. Vasquez [180], G.A. Vasquez [34b], F. Vazeille [36], T. Vazquez Schroeder [89], J. Veatch [56], V. Veeraraghavan [7], L.M. Veloce [162], F. Veloso [127a,127c], S. Veneziano [133a], A. Ventura [75a,75b], M. Venturi [173], N. Venturi [162], A. Venturini [25], V. Vercesi [122a], M. Verducci [133a,133b], W. Verkerke [108], J.C. Vermeulen [108], A. Vest [46,at], M.C. Vetterli [145,d], O. Viazlo [83], I. Vichou [170,*], T. Vickey [142], O.E. Vickey Boeriu [142], G.H.A. Viehhauser [121], S. Viel [16], L. Vigani [121], M. Villa [22a,22b], M. Villaplana Perez [93a,93b], E. Vilucchi [49], M.G. Vincter [31], V.B. Vinogradov [67], C. Vittori [22a,22b], I. Vivarelli [152], S. Vlachos [10], M. Vlasak [129], M. Vogel [179], P. Vokac [129], G. Volpi [125a,125b], M. Volpi [90], H. von der Schmitt [102], E. von Toerne [23], V. Vorobel [130], K. Vorobev [99], M. Vos [171], R. Voss [32], J.H. Vossebeld [76], N. Vranjes [14], M. Vranjes Milosavljevic [14], V. Vrba [128], M. Vreeswijk [108], R. Vuillermet [32], I. Vukotic [33], Z. Vykydal [129], P. Wagner [23], W. Wagner [179], H. Wahlberg [73], S. Wahrmund [46], J. Wakabayashi [104], J. Walder [74], R. Walker [101], W. Walkowiak [144], V. Wallangen [149a,149b], C. Wang [35b], C. Wang [140,87], F. Wang [177], H. Wang [16], H. Wang [42], J. Wang [44], J. Wang [153], K. Wang [89], R. Wang [6], S.M. Wang [154], T. Wang [23], T. Wang [37], W. Wang [59], C. Wanotayaroj [117], A. Warburton [89], C.P. Ward [30], D.R. Wardrope [80], A. Washbrook [48], P.M. Watkins [19], A.T. Watson [19], M.F. Watson [19], G. Watts [139], S. Watts [86], B.M. Waugh [80], S. Webb [85], M.S. Weber [18], S.W. Weber [178], S.A. Weber [31], J.S. Webster [6], A.R. Weidberg [121], B. Weinert [63], J. Weingarten [56], C. Weiser [50], H. Weits [108], P.S. Wells [32], T. Wenaus [27], T. Wengler [32], S. Wenig [32], N. Wermes [23], M. Werner [50], M.D. Werner [66], P. Werner [32], M. Wessels [60a], J. Wetter [166], K. Whalen [117], N.L. Whallon [139], A.M. Wharton [74], A. White [8], M.J. White [1], R. White [34b], D. Whiteson [167], F.J. Wickens [132], W. Wiedenmann [177], M. Wielers [132], C. Wiglesworth [38], L.A.M. Wiik-Fuchs [23], A. Wildauer [102], F. Wilk [86], H.G. Wilkens [32], H.H. Williams [123], S. Williams [108], C. Willis [92], S. Willocq [88], J.A. Wilson [19], I. Wingerter-Seez [5], F. Winklmeier [117], O.J. Winston [152], B.T. Winter [23], M. Wittgen [146], J. Wittkowski [101], T.M.H. Wolf [108], M.W. Wolter [41], H. Wolters [127a,127c], S.D. Worm [132], B.K. Wosiek [41], J. Wotschack [32], M.J. Woudstra [86], K.W. Wozniak [41], M. Wu [57], M. Wu [33], S.L. Wu [177], X. Wu [51], Y. Wu [91], T.R. Wyatt [86], B.M. Wynne [48], S. Xella [38], D. Xu [35a], L. Xu [27], B. Yabsley [153], S. Yacoob [148a], D. Yamaguchi [160], Y. Yamaguchi [119], A. Yamamoto [68], S. Yamamoto [158], T. Yamanaka [158],

K. Yamauchi [104], Y. Yamazaki [69], Z. Yan [24], H. Yang [141], H. Yang [177], Y. Yang [154], Z. Yang [15], W-M. Yao [16], Y.C. Yap [82], Y. Yasu [68], E. Yatsenko [5], K.H. Yau Wong [23], J. Ye [42], S. Ye [27], I. Yeletskikh [67], E. Yildirim [85], K. Yorita [175], R. Yoshida [6], K. Yoshihara [123], C. Young [146], C.J.S. Young [32], S. Youssef [24], D.R. Yu [16], J. Yu [8], J.M. Yu [91], J. Yu [66], L. Yuan [69], S.P.Y. Yuen [23], I. Yusuff [30,au], B. Zabinski [41], R. Zaidan [65], A.M. Zaitsev [131,ae], N. Zakharchuk [44], J. Zalieckas [15], A. Zaman [151], S. Zambito [58], L. Zanello [133a,133b], D. Zanzi [90], C. Zeitnitz [179], M. Zeman [129], A. Zemla [40a], J.C. Zeng [170], Q. Zeng [146], O. Zenin [131], T. Ženiš [147a], D. Zerwas [118], D. Zhang [91], F. Zhang [177], G. Zhang [59,ao], H. Zhang [35b], J. Zhang [6], L. Zhang [50], M. Zhang [170], R. Zhang [23], R. Zhang [59,av], X. Zhang [140], Z. Zhang [118], X. Zhao [42], Y. Zhao [140], Z. Zhao [59], A. Zhemchugov [67], J. Zhong [121], B. Zhou [91], C. Zhou [177], L. Zhou [37], L. Zhou [42], M. Zhou [151], N. Zhou [35c], C.G. Zhu [140], H. Zhu [35a], J. Zhu [91], Y. Zhu [59], X. Zhuang [35a], K. Zhukov [97], A. Zibell [178], D. Zieminska [63], N.I. Zimine [67], C. Zimmermann [85], S. Zimmermann [50], Z. Zinonos [56], M. Zinser [85], M. Ziolkowski [144], L. Živković [14], G. Zobernig [177], A. Zoccoli [22a,22b], M. zur Nedden [17], L. Zwalinski [32]

[1] Department of Physics, University of Adelaide, Adelaide, Australia
[2] Physics Department, SUNY Albany, Albany, NY, United States
[3] Department of Physics, University of Alberta, Edmonton, AB, Canada
[4] [(a)] Department of Physics, Ankara University, Ankara; [(b)] Istanbul Aydin University, Istanbul; [(c)] Division of Physics, TOBB University of Economics and Technology, Ankara, Turkey
[5] LAPP, CNRS/IN2P3 and Université Savoie Mont Blanc, Annecy-le-Vieux, France
[6] High Energy Physics Division, Argonne National Laboratory, Argonne, IL, United States
[7] Department of Physics, University of Arizona, Tucson, AZ, United States
[8] Department of Physics, The University of Texas at Arlington, Arlington, TX, United States
[9] Physics Department, University of Athens, Athens, Greece
[10] Physics Department, National Technical University of Athens, Zografou, Greece
[11] Department of Physics, The University of Texas at Austin, Austin, TX, United States
[12] Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan
[13] Institut de Física d'Altes Energies (IFAE), The Barcelona Institute of Science and Technology, Barcelona, Spain
[14] Institute of Physics, University of Belgrade, Belgrade, Serbia
[15] Department for Physics and Technology, University of Bergen, Bergen, Norway
[16] Physics Division, Lawrence Berkeley National Laboratory and University of California, Berkeley, CA, United States
[17] Department of Physics, Humboldt University, Berlin, Germany
[18] Albert Einstein Center for Fundamental Physics and Laboratory for High Energy Physics, University of Bern, Bern, Switzerland
[19] School of Physics and Astronomy, University of Birmingham, Birmingham, United Kingdom
[20] [(a)] Department of Physics, Bogazici University, Istanbul; [(b)] Department of Physics Engineering, Gaziantep University, Gaziantep; [(d)] Istanbul Bilgi University, Faculty of Engineering and Natural Sciences, Istanbul, Turkey; [(e)] Bahcesehir University, Faculty of Engineering and Natural Sciences, Istanbul, Turkey
[21] Centro de Investigaciones, Universidad Antonio Narino, Bogota, Colombia
[22] [(a)] INFN Sezione di Bologna; [(b)] Dipartimento di Fisica e Astronomia, Università di Bologna, Bologna, Italy
[23] Physikalisches Institut, University of Bonn, Bonn, Germany
[24] Department of Physics, Boston University, Boston, MA, United States
[25] Department of Physics, Brandeis University, Waltham, MA, United States
[26] [(a)] Universidade Federal do Rio De Janeiro COPPE/EE/IF, Rio de Janeiro; [(b)] Electrical Circuits Department, Federal University of Juiz de Fora (UFJF), Juiz de Fora; [(c)] Federal University of Sao Joao del Rei (UFSJ), Sao Joao del Rei; [(d)] Instituto de Fisica, Universidade de Sao Paulo, Sao Paulo, Brazil
[27] Physics Department, Brookhaven National Laboratory, Upton, NY, United States
[28] [(a)] Transilvania University of Brasov, Brasov, Romania; [(b)] National Institute of Physics and Nuclear Engineering, Bucharest; [(c)] National Institute for Research and Development of Isotopic and Molecular Technologies, Physics Department, Cluj Napoca; [(d)] University Politehnica Bucharest, Bucharest; [(e)] West University in Timisoara, Timisoara, Romania
[29] Departamento de Física, Universidad de Buenos Aires, Buenos Aires, Argentina
[30] Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom
[31] Department of Physics, Carleton University, Ottawa, ON, Canada
[32] CERN, Geneva, Switzerland
[33] Enrico Fermi Institute, University of Chicago, Chicago, IL, United States
[34] [(a)] Departamento de Física, Pontificia Universidad Católica de Chile, Santiago; [(b)] Departamento de Física, Universidad Técnica Federico Santa María, Valparaíso, Chile
[35] [(a)] Institute of High Energy Physics, Chinese Academy of Sciences, Beijing; [(b)] Department of Physics, Nanjing University, Jiangsu; [(c)] Physics Department, Tsinghua University, Beijing 100084, China
[36] Laboratoire de Physique Corpusculaire, Clermont Université and Université Blaise Pascal and CNRS/IN2P3, Clermont-Ferrand, France
[37] Nevis Laboratory, Columbia University, Irvington, NY, United States
[38] Niels Bohr Institute, University of Copenhagen, Kobenhavn, Denmark
[39] [(a)] INFN Gruppo Collegato di Cosenza, Laboratori Nazionali di Frascati; [(b)] Dipartimento di Fisica, Università della Calabria, Rende, Italy
[40] [(a)] AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow; [(b)] Marian Smoluchowski Institute of Physics, Jagiellonian University, Krakow, Poland
[41] Institute of Nuclear Physics Polish Academy of Sciences, Krakow, Poland
[42] Physics Department, Southern Methodist University, Dallas, TX, United States
[43] Physics Department, University of Texas at Dallas, Richardson, TX, United States
[44] DESY, Hamburg and Zeuthen, Germany
[45] Lehrstuhl für Experimentelle Physik IV, Technische Universität Dortmund, Dortmund, Germany
[46] Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Dresden, Germany
[47] Department of Physics, Duke University, Durham, NC, United States
[48] SUPA - School of Physics and Astronomy, University of Edinburgh, Edinburgh, United Kingdom
[49] INFN Laboratori Nazionali di Frascati, Frascati, Italy
[50] Fakultät für Mathematik und Physik, Albert-Ludwigs-Universität, Freiburg, Germany
[51] Section de Physique, Université de Genève, Geneva, Switzerland
[52] [(a)] INFN Sezione di Genova; [(b)] Dipartimento di Fisica, Università di Genova, Genova, Italy
[53] [(a)] E. Andronikashvili Institute of Physics, Iv. Javakhishvili Tbilisi State University, Tbilisi; [(b)] High Energy Physics Institute, Tbilisi State University, Tbilisi, Georgia
[54] II Physikalisches Institut, Justus-Liebig-Universität Giessen, Giessen, Germany
[55] SUPA - School of Physics and Astronomy, University of Glasgow, Glasgow, United Kingdom

[56] II Physikalisches Institut, Georg-August-Universität, Göttingen, Germany
[57] Laboratoire de Physique Subatomique et de Cosmologie, Université Grenoble-Alpes, CNRS/IN2P3, Grenoble, France
[58] Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, MA, United States
[59] Department of Modern Physics, University of Science and Technology of China, Anhui, China
[60] [(a)] Kirchhoff-Institut für Physik, Ruprecht-Karls-Universität Heidelberg, Heidelberg; [(b)] Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Heidelberg; [(c)] ZITI Institut für technische Informatik, Ruprecht-Karls-Universität Heidelberg, Mannheim, Germany
[61] Faculty of Applied Information Science, Hiroshima Institute of Technology, Hiroshima, Japan
[62] [(a)] Department of Physics, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong; [(b)] Department of Physics, The University of Hong Kong, Hong Kong; [(c)] Department of Physics and Institute for Advanced Study, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, China
[63] Department of Physics, Indiana University, Bloomington, IN, United States
[64] Institut für Astro- und Teilchenphysik, Leopold-Franzens-Universität, Innsbruck, Austria
[65] University of Iowa, Iowa City, IA, United States
[66] Department of Physics and Astronomy, Iowa State University, Ames, IA, United States
[67] Joint Institute for Nuclear Research, JINR Dubna, Dubna, Russia
[68] KEK, High Energy Accelerator Research Organization, Tsukuba, Japan
[69] Graduate School of Science, Kobe University, Kobe, Japan
[70] Faculty of Science, Kyoto University, Kyoto, Japan
[71] Kyoto University of Education, Kyoto, Japan
[72] Department of Physics, Kyushu University, Fukuoka, Japan
[73] Instituto de Física La Plata, Universidad Nacional de La Plata and CONICET, La Plata, Argentina
[74] Physics Department, Lancaster University, Lancaster, United Kingdom
[75] [(a)] INFN Sezione di Lecce; [(b)] Dipartimento di Matematica e Fisica, Università del Salento, Lecce, Italy
[76] Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom
[77] Department of Physics, Jožef Stefan Institute and University of Ljubljana, Ljubljana, Slovenia
[78] School of Physics and Astronomy, Queen Mary University of London, London, United Kingdom
[79] Department of Physics, Royal Holloway University of London, Surrey, United Kingdom
[80] Department of Physics and Astronomy, University College London, London, United Kingdom
[81] Louisiana Tech University, Ruston, LA, United States
[82] Laboratoire de Physique Nucléaire et de Hautes Energies, UPMC and Université Paris-Diderot and CNRS/IN2P3, Paris, France
[83] Fysiska institutionen, Lunds universitet, Lund, Sweden
[84] Departamento de Fisica Teorica C-15, Universidad Autonoma de Madrid, Madrid, Spain
[85] Institut für Physik, Universität Mainz, Mainz, Germany
[86] School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom
[87] CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France
[88] Department of Physics, University of Massachusetts, Amherst, MA, United States
[89] Department of Physics, McGill University, Montreal, QC, Canada
[90] School of Physics, University of Melbourne, Victoria, Australia
[91] Department of Physics, The University of Michigan, Ann Arbor, MI, United States
[92] Department of Physics and Astronomy, Michigan State University, East Lansing, MI, United States
[93] [(a)] INFN Sezione di Milano; [(b)] Dipartimento di Fisica, Università di Milano, Milano, Italy
[94] B.I. Stepanov Institute of Physics, National Academy of Sciences of Belarus, Minsk, Belarus
[95] National Scientific and Educational Centre for Particle and High Energy Physics, Minsk, Belarus
[96] Group of Particle Physics, University of Montreal, Montreal, QC, Canada
[97] P.N. Lebedev Physical Institute of the Russian Academy of Sciences, Moscow, Russia
[98] Institute for Theoretical and Experimental Physics (ITEP), Moscow, Russia
[99] National Research Nuclear University MEPhI, Moscow, Russia
[100] D.V. Skobeltsyn Institute of Nuclear Physics, M.V. Lomonosov Moscow State University, Moscow, Russia
[101] Fakultät für Physik, Ludwig-Maximilians-Universität München, München, Germany
[102] Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München, Germany
[103] Nagasaki Institute of Applied Science, Nagasaki, Japan
[104] Graduate School of Science and Kobayashi-Maskawa Institute, Nagoya University, Nagoya, Japan
[105] [(a)] INFN Sezione di Napoli; [(b)] Dipartimento di Fisica, Università di Napoli, Napoli, Italy
[106] Department of Physics and Astronomy, University of New Mexico, Albuquerque, NM, United States
[107] Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands
[108] Nikhef National Institute for Subatomic Physics and University of Amsterdam, Amsterdam, Netherlands
[109] Department of Physics, Northern Illinois University, DeKalb, IL, United States
[110] Budker Institute of Nuclear Physics, SB RAS, Novosibirsk, Russia
[111] Department of Physics, New York University, New York, NY, United States
[112] Ohio State University, Columbus, OH, United States
[113] Faculty of Science, Okayama University, Okayama, Japan
[114] Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, Norman, OK, United States
[115] Department of Physics, Oklahoma State University, Stillwater, OK, United States
[116] Palacký University, RCPTM, Olomouc, Czechia
[117] Center for High Energy Physics, University of Oregon, Eugene, OR, United States
[118] LAL, Univ. Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, Orsay, France
[119] Graduate School of Science, Osaka University, Osaka, Japan
[120] Department of Physics, University of Oslo, Oslo, Norway
[121] Department of Physics, Oxford University, Oxford, United Kingdom
[122] [(a)] INFN Sezione di Pavia; [(b)] Dipartimento di Fisica, Università di Pavia, Pavia, Italy
[123] Department of Physics, University of Pennsylvania, Philadelphia, PA, United States
[124] National Research Centre "Kurchatov Institute" B.P.Konstantinov Petersburg Nuclear Physics Institute, St. Petersburg, Russia
[125] [(a)] INFN Sezione di Pisa; [(b)] Dipartimento di Fisica E. Fermi, Università di Pisa, Pisa, Italy
[126] Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, PA, United States
[127] [(a)] Laboratório de Instrumentação e Física Experimental de Partículas - LIP, Lisboa; [(b)] Faculdade de Ciências, Universidade de Lisboa, Lisboa; [(c)] Department of Physics, University of Coimbra, Coimbra; [(d)] Centro de Física Nuclear da Universidade de Lisboa, Lisboa; [(e)] Departamento de Fisica, Universidade do Minho, Braga; [(f)] Departamento de Fisica Teorica y del Cosmos and CAFPE, Universidad de Granada, Granada (Spain); [(g)] Dep Fisica and CEFITEC of Faculdade de Ciencias e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal
[128] Institute of Physics, Academy of Sciences of the Czech Republic, Praha, Czechia
[129] Czech Technical University in Prague, Praha, Czechia
[130] Faculty of Mathematics and Physics, Charles University in Prague, Praha, Czechia

[131] *State Research Center Institute for High Energy Physics (Protvino), NRC KI, Russia*
[132] *Particle Physics Department, Rutherford Appleton Laboratory, Didcot, United Kingdom*
[133] [(a)] *INFN Sezione di Roma;* [(b)] *Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy*
[134] [(a)] *INFN Sezione di Roma Tor Vergata;* [(b)] *Dipartimento di Fisica, Università di Roma Tor Vergata, Roma, Italy*
[135] [(a)] *INFN Sezione di Roma Tre;* [(b)] *Dipartimento di Matematica e Fisica, Università Roma Tre, Roma, Italy*
[136] [(a)] *Faculté des Sciences Ain Chock, Réseau Universitaire de Physique des Hautes Energies - Université Hassan II, Casablanca;* [(b)] *Centre National de l'Energie des Sciences Techniques Nucleaires, Rabat;* [(c)] *Faculté des Sciences Semlalia, Université Cadi Ayyad, LPHEA-Marrakech;* [(d)] *Faculté des Sciences, Université Mohamed Premier and LPTPM, Oujda;* [(e)] *Faculté des sciences, Université Mohammed V, Rabat, Morocco*
[137] *DSM/IRFU (Institut de Recherches sur les Lois Fondamentales de l'Univers), CEA Saclay (Commissariat à l'Energie Atomique et aux Energies Alternatives), Gif-sur-Yvette, France*
[138] *Santa Cruz Institute for Particle Physics, University of California Santa Cruz, Santa Cruz, CA, United States*
[139] *Department of Physics, University of Washington, Seattle, WA, United States*
[140] *School of Physics, Shandong University, Shandong, China*
[141] *Department of Physics and Astronomy, Shanghai Key Laboratory for Particle Physics and Cosmology, Shanghai Jiao Tong University, Shanghai, China* [aw]
[142] *Department of Physics and Astronomy, University of Sheffield, Sheffield, United Kingdom*
[143] *Department of Physics, Shinshu University, Nagano, Japan*
[144] *Fachbereich Physik, Universität Siegen, Siegen, Germany*
[145] *Department of Physics, Simon Fraser University, Burnaby, BC, Canada*
[146] *SLAC National Accelerator Laboratory, Stanford, CA, United States*
[147] [(a)] *Faculty of Mathematics, Physics & Informatics, Comenius University, Bratislava;* [(b)] *Department of Subnuclear Physics, Institute of Experimental Physics of the Slovak Academy of Sciences, Kosice, Slovak Republic*
[148] [(a)] *Department of Physics, University of Cape Town, Cape Town;* [(b)] *Department of Physics, University of Johannesburg, Johannesburg;* [(c)] *School of Physics, University of the Witwatersrand, Johannesburg, South Africa*
[149] [(a)] *Department of Physics, Stockholm University;* [(b)] *The Oskar Klein Centre, Stockholm, Sweden*
[150] *Physics Department, Royal Institute of Technology, Stockholm, Sweden*
[151] *Departments of Physics & Astronomy and Chemistry, Stony Brook University, Stony Brook, NY, United States*
[152] *Department of Physics and Astronomy, University of Sussex, Brighton, United Kingdom*
[153] *School of Physics, University of Sydney, Sydney, Australia*
[154] *Institute of Physics, Academia Sinica, Taipei, Taiwan*
[155] *Department of Physics, Technion: Israel Institute of Technology, Haifa, Israel*
[156] *Raymond and Beverly Sackler School of Physics and Astronomy, Tel Aviv University, Tel Aviv, Israel*
[157] *Department of Physics, Aristotle University of Thessaloniki, Thessaloniki, Greece*
[158] *International Center for Elementary Particle Physics and Department of Physics, The University of Tokyo, Tokyo, Japan*
[159] *Graduate School of Science and Technology, Tokyo Metropolitan University, Tokyo, Japan*
[160] *Department of Physics, Tokyo Institute of Technology, Tokyo, Japan*
[161] *Tomsk State University, Tomsk, Russia*
[162] *Department of Physics, University of Toronto, Toronto, ON, Canada*
[163] [(a)] *INFN-TIFPA;* [(b)] *University of Trento, Trento, Italy*
[164] [(a)] *TRIUMF, Vancouver, BC;* [(b)] *Department of Physics and Astronomy, York University, Toronto, ON, Canada*
[165] *Faculty of Pure and Applied Sciences, and Center for Integrated Research in Fundamental Science and Engineering, University of Tsukuba, Tsukuba, Japan*
[166] *Department of Physics and Astronomy, Tufts University, Medford, MA, United States*
[167] *Department of Physics and Astronomy, University of California Irvine, Irvine, CA, United States*
[168] [(a)] *INFN Gruppo Collegato di Udine, Sezione di Trieste, Udine;* [(b)] *ICTP, Trieste;* [(c)] *Dipartimento di Chimica, Fisica e Ambiente, Università di Udine, Udine, Italy*
[169] *Department of Physics and Astronomy, University of Uppsala, Uppsala, Sweden*
[170] *Department of Physics, University of Illinois, Urbana, IL, United States*
[171] *Instituto de Fisica Corpuscular (IFIC) and Departamento de Fisica Atomica, Molecular y Nuclear and Departamento de Ingeniería Electrónica and Instituto de Microelectrónica de Barcelona (IMB-CNM), University of Valencia and CSIC, Valencia, Spain*
[172] *Department of Physics, University of British Columbia, Vancouver, BC, Canada*
[173] *Department of Physics and Astronomy, University of Victoria, Victoria, BC, Canada*
[174] *Department of Physics, University of Warwick, Coventry, United Kingdom*
[175] *Waseda University, Tokyo, Japan*
[176] *Department of Particle Physics, The Weizmann Institute of Science, Rehovot, Israel*
[177] *Department of Physics, University of Wisconsin, Madison, WI, United States*
[178] *Fakultät für Physik und Astronomie, Julius-Maximilians-Universität, Würzburg, Germany*
[179] *Fakultät für Mathematik und Naturwissenschaften, Fachgruppe Physik, Bergische Universität Wuppertal, Wuppertal, Germany*
[180] *Department of Physics, Yale University, New Haven, CT, United States*
[181] *Yerevan Physics Institute, Yerevan, Armenia*
[182] *Centre de Calcul de l'Institut National de Physique Nucléaire et de Physique des Particules (IN2P3), Villeurbanne, France*

[a] Also at Department of Physics, King's College London, London, United Kingdom.
[b] Also at Institute of Physics, Azerbaijan Academy of Sciences, Baku, Azerbaijan.
[c] Also at Novosibirsk State University, Novosibirsk, Russia.
[d] Also at TRIUMF, Vancouver BC, Canada.
[e] Also at Department of Physics & Astronomy, University of Louisville, Louisville, KY, United States.
[f] Also at Physics Department, An-Najah National University, Nablus, Palestine.
[g] Also at Department of Physics, California State University, Fresno, CA, United States.
[h] Also at Department of Physics, University of Fribourg, Fribourg, Switzerland.
[i] Also at Departament de Fisica de la Universitat Autonoma de Barcelona, Barcelona, Spain.
[j] Also at Departamento de Fisica e Astronomia, Faculdade de Ciencias, Universidade do Porto, Portugal.
[k] Also at Tomsk State University, Tomsk, Russia, Russia.
[l] Also at Universita di Napoli Parthenope, Napoli, Italy.
[m] Also at Institute of Particle Physics (IPP), Canada.
[n] Also at National Institute of Physics and Nuclear Engineering, Bucharest, Romania.
[o] Also at Department of Physics, St. Petersburg State Polytechnical University, St. Petersburg, Russia.
[p] Also at Department of Physics, The University of Michigan, Ann Arbor, MI, United States.
[q] Also at Centre for High Performance Computing, CSIR Campus, Rosebank, Cape Town, South Africa.
[r] Also at Louisiana Tech University, Ruston, LA, United States.
[s] Also at Institucio Catalana de Recerca i Estudis Avancats, ICREA, Barcelona, Spain.

[t] Also at Graduate School of Science, Osaka University, Osaka, Japan.
[u] Also at Department of Physics, National Tsing Hua University, Taiwan.
[v] Also at Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen/Nikhef, Nijmegen, Netherlands.
[w] Also at Department of Physics, The University of Texas at Austin, Austin, TX, United States.
[x] Also at CERN, Geneva, Switzerland.
[y] Also at Georgian Technical University (GTU),Tbilisi, Georgia.
[z] Also at Ochadai Academic Production, Ochanomizu University, Tokyo, Japan.
[aa] Also at Manhattan College, New York, NY, United States.
[ab] Also at Academia Sinica Grid Computing, Institute of Physics, Academia Sinica, Taipei, Taiwan.
[ac] Also at School of Physics, Shandong University, Shandong, China.
[ad] Also at Department of Physics, California State University, Sacramento, CA, United States.
[ae] Also at Moscow Institute of Physics and Technology State University, Dolgoprudny, Russia.
[af] Also at Section de Physique, Université de Genève, Geneva, Switzerland.
[ag] Also at Eotvos Lorand University, Budapest, Hungary.
[ah] Also at Departments of Physics & Astronomy and Chemistry, Stony Brook University, Stony Brook, NY, United States.
[ai] Also at International School for Advanced Studies (SISSA), Trieste, Italy.
[aj] Also at Department of Physics and Astronomy, University of South Carolina, Columbia, SC, United States.
[ak] Also at Institut de Física d'Altes Energies (IFAE), The Barcelona Institute of Science and Technology, Barcelona, Spain.
[al] Also at School of Physics and Engineering, Sun Yat-sen University, Guangzhou, China.
[am] Also at Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences, Sofia, Bulgaria.
[an] Also at Faculty of Physics, M.V.Lomonosov Moscow State University, Moscow, Russia.
[ao] Also at Institute of Physics, Academia Sinica, Taipei, Taiwan.
[ap] Associated at Durham University, IPPP, Durham, United Kingdom, United Kingdom.
[aq] Also at National Research Nuclear University MEPhI, Moscow, Russia.
[ar] Also at Department of Physics, Stanford University, Stanford, CA, United States.
[as] Also at Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Budapest, Hungary.
[at] Also at Flensburg University of Applied Sciences, Flensburg, Germany.
[au] Also at University of Malaya, Department of Physics, Kuala Lumpur, Malaysia.
[av] Also at CPPM, Aix-Marseille Université and CNRS/IN2P3, Marseille, France.
[aw] Also affiliated with PKU-CHEP.
[*] Deceased.